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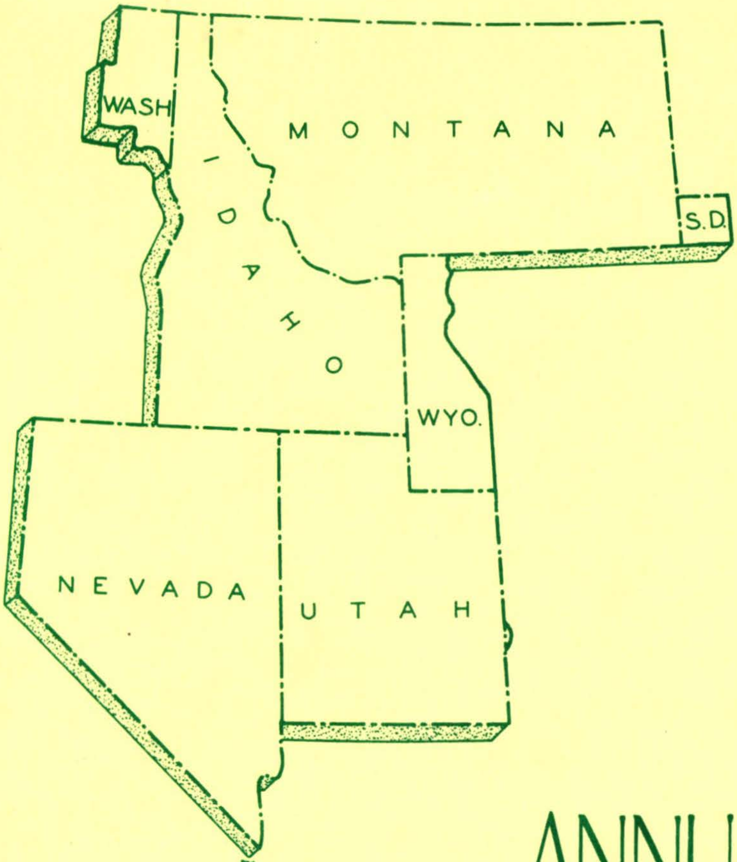
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1955

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

1905-1955
50 YEARS
GOLDEN ANNIVERSARY

OGDEN, UTAH

REED W. BAILEY
DIRECTOR

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A LOOK AHEAD

> "You will see to it that the water, wood, and forage of the reserves are conserved and wisely used...and where conflicting interests must be reconciled the question will always be decided from the standpoint of the greatest good of the greatest number in the long run."

The instructions given by Secretary Wilson to the newly launched Forest Service fifty years ago were fundamental and prophetic. Much progress has been made within the framework of this philosophy and we can be sure that it will continue to serve well the future managers of our wild lands.

These instructions, however, did not specify how they could be carried out. How should the timber be cut and the forage grazed to assure perpetuity of these renewable resources? How should the forests and grazing lands be managed to protect the water supplies originating in them? Instructions did not spell out what forest and range practices were necessary to assure the attainment of that attractive and motivating slogan "the greatest good of the greatest number in the long run."

Nevertheless, we can truthfully say that important progress has been made, since those early stalwarts launched the national forest system, in all phases of forest and range land management and in all ownerships. Through trial and error, experience, and limited research, forestry has come a long way on the road of conservation through use.

On the basis of the record of the past fifty years, and the experience and knowledge we have gained, we can see in general outline the picture of forestry of the future, and it looks good. We are sure that the products and services of the Nation's forests and ranges will be in great demand. They will play an ever-increasing role in the economic, social, and spiritual growth of the country. They will be essential to that growth and will not be made obsolete by an atomic and chemical age.

The uses to which wood will be put in the future are limited only by the scope of our ingenuity and ability to juggle the molecules of cellulose. Wood fiber from inferior species of trees and wood scraps from our mills will be turned into an amazing array of cloth, paper, lacquer, plastic, and fiberboard products. Through wood chemistry will come products as varied as stock-feed molasses and industrial acid. Improved glues and new techniques will permit the creation of large materials of any shape from small cheap wood pieces. We are now using laminated wood arches with spans as great as 200 feet. In the future we will see, in full production, laminated products ranging from baseball bats to bridge timbers.

As a result of the new uses of wood and the new processes, many so-called weed species of trees will become wanted and valuable. They will take some of the pressure off the present high-grade species. They will provide markets for small-sized billets, posts, and poles so that cultural treatment in young stands will be feasible. The great array of marketable products will permit harvest cuttings of whatever shape, size, form, or variety best suits the needs of management. With all the new uses for inferior materials, high-grade timber will still have an important place and its need in the Nation's construction program will increase as indicated by the present demand and price of large clear boards. In growing better wood and growing it faster, we will employ the science of genetics and during the next fifty years trees improved through breeding and selection will be in production.

Recreational use of forest lands will increase beyond the imaginations of most of us. With the growth of urbanization, use of the woods, streams, lakes, and mountains to satisfy the esthetic and spiritual needs of men have increased manyfold during the past fifty years, and such needs will increase in geometric proportions during the next half century.

Range use reached the saturation point early in the history of western grazing. But the demand for forage, by both livestock and game, has steadily increased over the years. Although many adjustments in the numbers of animals grazed are yet to be made, rehabilitation of deteriorated range lands through reseeding and improved management practices gives fair promise of increased use in the future. Grazing of livestock and big game is the only means of harvesting the valuable forage crops that large areas of lands in the West are capable of growing. Future plans call for reaping this harvest on a sustained yield basis.

Water, the most essential product of our wild lands, continues to be a critical need and will be a limiting factor in our future progress. Our rapidly growing population, with the need for more and more food, and the industrialization of all parts of the country, are calling for more and better quality water. Multi-million dollar programs for development of major river systems illustrate the extent to which the public will go and must go in the development of its water supply. But dams alone will not do the job of water conservation. The forest and range lands on which the waters originate must be made to function to regulate streamflow and control sediment production. We know now that the manner in which timber is cut, roads are built, and animals--whether domestic livestock or wild game--are grazed on the watersheds of our streams, have much to do with maintaining the useful life of reservoirs. Forest and range use plans must be geared to the requirements for production of usable water.

This is critically impelling and cannot be denied if our communities and industries are to survive and grow. The small beginnings in watershed management recently launched will become the principal objective of utilization and management in the future throughout much of the country. Water conservation programs of the future will be unified and they will provide not only for well-constructed multiple-use dams but, in addition, for scientifically designed forest and range use practices. The new era of wild land management will be marked by practices designed to make forest and range lands fully productive. Uses will be based on technically sound consideration of the hydrologic as well as productive limits and potentialities of the land.

The first fifty years in the life of the Forest Service has seen a marked trend in wild land management generally away from a long era of exploitation. These past practices had both good and bad results. They fostered a rapid movement of population westward across this continent and made available the timber and forage that were needed for a growing nation. But this exploitation left the nation poorer in reserves of timber, forage, and wildlife, in acreages of stable soil, and in the regularity and clarity of streamflow. Progress during the past fifty years is primarily to be measured in the stopping of abusive practices of exploitation and substituting for them such better practices as lay at hand or could be improvised. With the passage of time and as scientific research has provided better understanding, many of these early management practices have been improved.

Progress during the next fifty years will be measured primarily in terms of effective management. Future progress, as envisioned both by dreamers and practical-minded land managers, is predicated upon enlightened public attitudes, more and better trained technicians, and the acquisition of knowledge through research. Our experience tells us that education and research are basic. We live in a Republic where democratic practices must be fostered and protected. Research programs must be enlarged and strengthened. Although the general goals of wild land management have become clear, many methods and procedures, principles, and concepts must be worked out by the scientific method before these goals can be reached.

In the following pages, the Intermountain Forest and Range Experiment Station presents its annual report, as it has done each year most of the forty years of its existence. These past reports reflect, each in its own way, our understanding of wild land problems at a particular time and the nature of progress being made. So it is with this report for 1955. For those who look back fifty years hence, may this report mark considerably less than the halfway point in a century of progress!

FOREST MANAGEMENT RESEARCH

A review of activities in Forest Management Research at the Intermountain Station during 1955 reveals a number of significant developments. One highlight, certainly, is the heightening interest in forest genetics research For several years the Station has participated actively in a program aimed at developing a blister rust-resistant western white pine in the Inland Empire. It has conducted field trials of hybrids produced by the Institute of Forest Genetics and carried out tree breeding projects in Montana and Idaho. Plans are now being laid for a possible future program of forest tree improvement through selection and breeding in southern Idaho. Local industrial and agency groups are interested and several meetings with genetics as the central theme have been held.

Another development deserving special mention is the increased effort being placed on regeneration studies. Launched last year with the assignment of a man primarily to this field of work, it is beginning to show results. During the past field season current research activity and status of regeneration knowledge, both natural and artificial, were reviewed for all major forest types in the Intermountain Station's area. As a result of this analysis, certain adjustments in program emphasis may be made. With insufficient resources to handle the job adequately alone, projects employing a cooperative approach are being organized. Both National Forest Administration and the forest industries have responded well to Station efforts in this direction. Several such coordinated studies are now under way.

Evident, also, during the past year is the increasing call for more and improved mensurational aids. Forest managers are asking the Station for better methods of determining site, for volume and yield tables, and for ways to estimate cull and defect. A closely allied interest in log grades is being expressed throughout the Intermountain area.

The above examples are simply indications of a very significant trend which became increasingly apparent in 1955. The virtues and wisdom of good forest management are being appreciated to a greater extent and are becoming more widely accepted in the area. Foresters and timberland owners want to manage their properties better and are turning to Research for facts and guiding principles. It is a healthy sign, and most assuredly a challenge to Forest Management Research at the Intermountain Station.

Selected items of progress from the Station's program in the Northern and Intermountain regions are presented below.

GENETICS

Breeding Blister Rust-Resistant Western White Pine of Good Growth and Quality

The western white pine breeding project is carried out in cooperation with the Spokane Unit, Blister Rust Control, National Forest Administration. For information on rust-resistance aspects of the project, the reader is referred to the latest annual report of this cooperator. Major items of progress in the vigor-quality phases follow:

1. Routine measurements on growth rate and crown form in progenies and grafted trees were continued. Large differences in growth rate and crown form and evidences of local ecotypes in progenies up to 4 years of age are still apparent.

2. The first group of progenies reserved for long-term studies of vigor and timber quality was outplanted last spring. Survival was not as good as desired, due primarily to winter damage of the stock in an off-site nursery at Missoula during the preceding winter. However, it is believed that sufficient numbers of seedlings survived to permit testing of most of the lots.

3. A series of flower induction tests was initiated. The main objective of these tests is to find the best means for stimulating early flowering in F_1 progenies in order to obtain second generation material as soon as possible. The studies will also yield information valuable for developing seed orchard techniques. The tests include: (a) Approach grafting of potted seedlings into the tops of 10- and 30-year-old trees. (b) A combined treatment of cultivating, fertilizing, and watering 10-year-old trees. (c) Approach grafting on hybrid rootstocks. A small-scale test made earlier showed that scions grafted onto eastern-western white pine hybrid rootstocks grew more rapidly than those grafted onto local western white pine rootstocks. (d) Fertilizing fruiting-age trees. (e) Cultivating, fertilizing, and watering seedlings with single and with all possible combinations of treatments. The technique used for top grafting was highly successful, 90 percent of the attempted grafts having made unions.

4. Cones produced in a selective fertilization test begun in 1954 were collected in the fall of 1955. Seed yield from the different crosses and the shape of the cone scales (see item 5 below) both indicate that some degree of selective fertilization (favoring crossing over selfing) likely occurred in at least one out of three tests involving different parents. The seeds will be sown in the spring of 1956. Since selfs are inherently smaller than crosses it is believed that a fairly reliable estimate of the amount of selective fertilization occurring will be obtained through segregation

of seedlings on the basis of first-year height. Parents used in the test were chosen on the basis of previous knowledge of the significant difference in first-year height of their crossed versus selfed progenies produced in the past.

5. Two tests designed to study variation in average seed weight of progenies produced through controlled pollination have been completed. These relationships were found to have a bearing on variation: (a) Seeds borne on shoots occurring in the upper and outer crown and on the south and west sides tended to be heavier than those borne in opposing portions of the crown. (b) Seeds borne on shoots containing larger numbers of cones tended to be slightly heavier than those on shoots having fewer cones. (c) Seeds in cones having relatively fewer sound seeds in relation to cone length tended to be heavier. The latter relationship suggested that pollen source could affect average seed weight indirectly through its effect upon seed yield. No significant direct effect of pollen source upon seed weight was found, however, and if such effects do occur they are likely to be small and easily obscured by environmental factors. Pollen source was shown to be associated with the average shape (width vs. length) of cone scales in some instances. Use of certain pollens resulted in scales which tended to be relatively narrow, while use of other pollens resulted in scales which tended to be comparatively wide. This is apparently an exemplification of metaxenia, or effect of pollen upon maternal tissues of the fruit, which has been shown to occur in some species (certainly in angiosperms), The study also demonstrated that in critical breeding experiments where it is desired that variation in seed weight and other traits be minimized, flowers should be carefully chosen, preferably through the use of an efficient statistical design. A followup test of possible metaxenial effects of pollen parents upon cones and seeds, especially the cone-scale shape, was initiated.

6. A test of osmotic pressure in seeds produced through controlled pollination conducted this year shows promise of being a useful tool in forest genetics work. Such tests have been reported as being effective in estimating genotypic traits in certain agricultural plants. The test as applied here involved cold water soaking, then germinating seeds on filter paper wetted with water or a weak sugar solution. Seed lots which germinated comparatively well in the sugar solution were considered as having a higher osmotic pressure, since they were able to imbibe water despite the adverse osmotic pressure of the germinating medium. The test was applied to 123 different seed lots, involving mostly intraspecies crosses and wind pollinations. Results showed a moderate inverse correlation of osmotic pressure with growth rate of progenies. Progeny seed lots of parents which apparently transmitted rapid growth rate in previous progeny trials (as measured in progenies up to 4 years of age) generally showed the lowest osmotic pressure values. Progeny

seeds of parents growing on the better sites displayed lower osmotic pressure than those from parent trees on poorer sites. This latter result furnished further evidence of the existence of local ecotypes in western white pine. Additional osmotic pressure tests are planned on wind-pollinated seeds collected from trees growing on a number of sites.

Field Tests of Hybrids

During 1955 field tests of lodgepole pine x jack pine hybrids produced by the Institute of Forest Genetics in California were maintained and new tests of locally produced hybrids were started. The new studies follow the same general design as the studies with hybrids from the Institute where growth and crown form are being tested. Locally produced lodgepole pine x jack pine hybrids (from the 1951 pollinations) were outplanted in two localities: Lubrecht Experimental Forest[1] in western Montana and Priest River Experimental Forest[2] in Idaho. Seed from the 1953 crosses were sown in Montana State Nursery at Missoula.

In another test, seed from other crosses made in 1953 using indigenous ponderosa pine seed parents were sown in the nursery. The species being tested are as follows:

Pinus ponderosa x *P. ponderosa* v. *scopulorum*
P. ponderosa x *P. engelmannii* (Apache pine)

Ponderosa Pine Variety Study

The Intermountain Station is assisting, along with other cooperators, in collecting material for a study of the racial strains of ponderosa pine being conducted by the Institute of Forest Genetics. Specimens of cones and foliage were collected at many points throughout the range of the species in the Station area. The study has two main objectives: (1) to provide information on racial variation of morphological and physiological characters in ponderosa pine, and (2) to accumulate a small supply of seed from various sources for cooperators who wish to conduct planting tests in their own localities of seed from other regions.

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[1] Maintained by Montana State University.

[2] Maintained by Intermountain Forest and Range Experiment Station.

REGENERATION

Partial Girdling Stimulated Seed Production in Young Ponderosa Pine Trees

In 1954 a study was installed to test release and partial girdling as possible stimulation measures to increase seed production of ponderosa pine. Young, immature, and mature trees of good vigor were selected at different places in the Bitterroot valley in western Montana for the test. Although conclusive results will not appear before the end of the 1956 growing season or later, a preliminary examination has revealed that partial girdling of 50-year-old trees accounted for an immediate increase in cone production over untreated trees. The partial girdling consisted of removing a continuous 1- to 2-inch-wide band of bark and cambium encircling the tree except for a 4-inch bridge of bark left intact. The results shown in table 1 were obtained by climbing the trees and counting the cones.

Table 1. Immature cones on 50-year-old ponderosa pines the second growing season after treatment

Tree number	Immature cones: Girdled	Immature cones: Control
	Number	Number
1	78	0
2	66	1
3	14	0
4	56	0
5	2	0
Total	216	1

Partially girdled trees in the two older age classes appear to be showing similar trends. However, these sample trees were examined with binoculars and because of the small size of immature cones, differences could not be accurately determined.

Effects of release as a stimulation measure have not been determined, but will be evaluated after the cones mature. Factors such as soundness, seed weight, viability, and seed yield will also be studied in detail at that time.

Ponderosa Pine Seed Crop for 1956 to be Poor

Based upon a ponderosa pine seed crop forecasting study on the Kootenai National Forest, the 1956 seed crop will be poor. In July 1955, 78 tagged branches on the 6 remaining trees in the study (originally there were 8) had only 49 conelets available for ripening in 1956, compared with 122 cones maturing on these same branches in July 1953 for the moderately good 1954 crop. All of the 1955 conelets were on only two of the trees. Assuming heavy squirrel cutting during the year of maturity, which has occurred in the past, and additional losses from other causes, a poor pine seed crop is forecast. Observations on the Lolo and Bitterroot National Forests indicate a poor seed crop for 1956 in these areas also.

Five-Year Results in a Lodgepole Pine Direct Seeding

In June 1950, an 11-acre plantation on a broadcast burned clear cutting in the Little Belt Mountains of central Montana was spot seeded to lodgepole pine. Rodents were poisoned in advance of seeding. Favorable weather prevailed, particularly during the germination period. By the end of the first growing season a successful plantation was established that had 74 percent of the seed spots stocked by one or more seedlings. Since original spacing was approximately 6 by 8 feet, there were 672 stocked spots per acre at this level of stocking.

During the ensuing 4 years there has been a slow, steady decline in the stocking of this plantation as shown in table 2. The average number of seedlings per spot has also decreased somewhat.

Table 2. Stocking of a spot-seeded lodgepole pine plantation at different examination periods

Date of examination	Stocked spots per acre	Seedlings per stocked spot	Stocked spots
	Number	Number	Percent
9-14-50	672	3.0	74
8-13-51	608	2.5	67
9-15-52	581	1/ -	64
6- 7-55	527	2.2	58

1/ No count made.

Height of the 5-year-old seedlings is somewhat disappointing, possibly because of competition afforded by the moderately dense stand of pine grass that developed by the end of the first year. Tallest seedlings averaged 0.6 foot and shortest 0.3 foot in height. Dominance is being asserted by numerous seedlings particularly where competition is reduced. Seedlings are expected to overtop the grass in another 2 years and should then grow more rapidly in height.

Lodgepole Pine Cone Opening Characteristics on Clear Cuttings

In July of 1955 investigations of factors affecting opening of persistent lodgepole pine cones in the logging slash on clear cuttings were started in central Montana. Previous studies had shown the importance of these cones as a seed source for natural regeneration. Furthermore, results indicated a tendency towards overstocking where slash had weathered during a summer season before piling for disposal. With greater knowledge about cone opening, methods of logging and slash disposal to control seedling density may be devised.

Some relationships are already becoming evident. Aspect and height above ground are important factors affecting cone opening. Not a single cone openly suspended one foot or higher above the surface opened during the growing season on either northerly or southerly aspects. Cones suspended 6 inches above the surface on southerly aspects partially opened but none at the 6-inch height opened on northerly aspects. Cones resting on the ground surface on southerly aspects opened rapidly and almost completely during the summer in contrast to those on northerly aspects where only a few cones opened during the same period.

On south-facing slopes, cones ranging from newly matured up to 10 years of age, lying on the ground, shed much of their seed during July and most of it by the end of August as shown in table 3. Trees were cut during May and June. Unopened cones were placed for testing on July 7.

Table 3. Proportion of total seed dispersed by lodgepole pine cones attached to branches placed unopened on a southeast-facing slope July 7, 1955, by period and cone age

Date of examination	Proportion of total seed dispersed by cones		
	Newly matured to 2 years old	3 to 9 years old	10 years old
	Percent	Percent	Percent
8-3-55	62.1	66.0	56.3
9-7-55	82.1	81.6	82.3
10-5-55	83.3	82.4	82.3

MENSURATION

Effects of Stocking on Site Evaluation and Yield

A manuscript was completed during 1955 on the effects of stocking on site measurement and yield of second-growth ponderosa pine. It will be published next year as a station paper.

Adjusted site index curves are presented for various conditions of stocking. Dense stocking retards height growth and thus influences the measure of site quality in such stands. Furthermore, the influence of dense stocking on height varies with site quality.

In addition to the adjusted site index curves, the manuscript presents a growth prediction system which considers the changes in stocking that overstocked and understocked stands pass through with advancing age.

Log Grading Plot Established

A plot of 71 mature ponderosa pine trees was established on the Boise Basin Experimental Forest to be used for training foresters in log grading. Personnel from the division of Timber Management (Region 4) and the Boise National Forest were assisted by a log grading specialist from Region 6 in assigning original grades to the logs in these standing trees. It is expected that log grading will eventually become a standard procedure in timber sales in Region 4, and this plot will help in achieving uniformity in the determination of log grades in standing trees.

HARVEST CUTTING

Results of Partial Cutting in Mature Western White Pine

Five-year records of sample plots in the Sheep Mountain Creek unit of the Clearwater National Forest show that net growth following partial cutting of this mature western white pine stand has been negative because of excessive mortality in the residual stand. Gross growth of the residual stand was good, averaging over 600 board feet per acre per year. However, excessive mortality reduced the net growth to minus 590 board feet per acre annually (table 4).

Table 4. Five-year growth per acre of mature western white pine stand following partial cutting

Stand	White pine volume	Total volume
	Board feet	Board feet
Before cutting	46,315	63,277
Removed	18,351	27,361
After cutting	27,964	35,916
5 years after cutting	24,293	32,967
5-year mortality	5,637	6,157
Gross increment	1,966	3,208
Net increment	-3,671	-2,949

Mortality was related to individual tree vigor even though caused for the most part by unusually high winds and buildup of beetle populations which might be expected to be less selective than normal levels of mortality. Records show that 13 percent of the good vigor trees, 20 percent of the fair vigor trees, and 35 percent of the poor vigor trees died during the period. In terms of board-foot volume proportionate losses were 12 percent, 18 percent, and 36 percent of the good, fair, and poor vigor classes respectively (table 5).

Table 5. Mortality in relation to vigor class of western white pine 5 years after partial cutting

White pine vigor class	Stand per acre after cutting		5-year mortality		Mortality percentage	
	Trees	Volume	Trees	Volume	Trees	Volume
	No.	Bd. ft.	No.	Bd. ft.	No.	Bd. ft.
Good	16.4	11,543	2.1	1,441	12.8	12.5
Fair	24.0	9,990	4.9	1,848	20.4	18.5
Poor	25.9	6,431	9.0	2,348	34.7	36.5
All classes	66.3	27,964	16.0	5,637	24.1	20.2

Vigor of the residual white pine stand in the Sheep Mountain Creek cutting declined even though mortality was lightest in the good vigor class. The proportion of white pine trees in the good vigor class dropped from 25 percent after cutting to 15 percent 5 years later.

Results of this study substantiate the conclusion from other partial cutting tests in mature western white pine stands that mortality is closely associated with tree vigor. They again emphasize the difficulty of predicting the occurrence of unusual mortality, especially in a small area. The decline in vigor following cutting agrees with the results of other tests which show that partial cutting should be restricted to vigorous stands in which at least 40 percent of the trees fall in the good vigor class. In thrifty stands, partial cutting has increased growth by removing poor vigor trees which are susceptible to mortality. In unthrifty stands cutting 40 to 50 percent of the stand often accelerates stand degeneration.

Ponderosa Pine Production Study

When the last of the 4,311,500 board feet of timber cut on the 16 compartments of the ponderosa pine production study, Boise Basin Experimental Forest, was loaded out in January 1955, the major part of the installation of this study was completed. There remained some fire hazard reduction and erosion control work to be done before the operation could be closed.

Most of the slash disposal work for the second 8 compartments had been done in the fall of 1954 by personnel of the Boise National Forest; the part that remained was completed during the following spring and summer. The same crews completed several erosion control measures in skid trails.

The late completion of log hauling made it necessary for the operator to construct temporary dikes for erosion control on the spur roads in most compartments. When ground conditions became favorable, they were replaced by cross ditches designed for greater permanence.

A major effort in this field season's work was the reexamination of all the sample plots in the first 8 compartments of the study (logged in 1953). These plots were designed to furnish data for appraising the differences in damage to the younger age classes resulting from the two sizes of logging tractors and two reserve volume levels tested.

The surveying of all spur roads, begun in 1954 to permit revision of experimental forest maps and to allow the exclusion of road area from acreage and volume calculations within compartments, has been completed.

A survey of sawtree mortality following logging was made in the compartments logged in 1953. Mortality from all causes for the 2-year period totalled 20.1 M.b.f. for an average of 45 board feet per acre. Of this, 40 percent is attributed to lightning, 37 percent to insects, 14 percent to road construction, and 9 percent to other causes.

Board-Foot Growth in a 120-to 220-Year-Old Ponderosa Pine Reserve

A knowledge of the growth capacity of partially cut ponderosa pine stands is necessary for planning the initial harvest in remaining old-growth stands and forecasting probable yield from subsequent cuts of reserve sawtimber. Twenty-year results of a cutting study in western Montana show that 4,000 to 8,000 board feet per acre of vigorous, well-spaced trees of moderate size make up an ample reserve for growth. As in previous studies gross board-foot growth was found to vary with reserve volume.

Reserve volume	20-year gross growth
Bd. ft.	Bd. ft.
2,018	945
4,150	1,948
10,004	2,362

Individual tree growth was also studied. The vigor of trees making up the reserve stand and the amount of growing space made available to them proved to be important factors in growth acceleration (table 6).

Table 6. Twenty-year growth per individual ponderosa pine tree, 120 to 220 years old, following two degrees of cutting, by initial diameter and vigor class

Initial d.b.h.	78 percent volume cut		41 percent volume cut	
(inches)	Good vigor	Fair vigor[1]	Good vigor	Fair vigor
	Board feet		Board feet	
12	69	-	55	30
16	122	-	77	58
20	175	-	99	86
24	228	-	121	114
28	282	-	143	142

[1] Values are the same as for good vigor trees. Since differences between adjusted means of the individual regressions were not significant, the data were combined into a single regression and the tabular values computed.

Information on growth of individual trees is valuable to the timber marker who must decide which trees to cut and which ones to leave for future production. Complete results of this study are to be published in a research paper in 1956.

Piquett Creek Experimental Forest

Volume estimates and initial samplings of insect risk were made in ponderosa pine at Piquett Creek on the Bitterroot National Forest. These estimates are to be used for determining the economic feasibility of developing a road system and making a light initial cut over the currently inactive experimental area. The work is being done in cooperation with National Forest Administration.

Volume data have not been completely analyzed. Risk data show that the proportion of trees in high-risk classes, as judged by Salman-Bongberg risk ratings, is 14.9 percent, about average for virgin ponderosa pine stands in the region.

Risk rating	Percentage of trees
I, low risk	35.1
II, moderate risk	50.0
III, high risk	13.1
IV, very high risk	1.8

Planning for the orderly extraction of the initial cut from Piquett Creek is to be continued in 1956.

Net Volume Growth in an Engelmann Spruce Reserve Stand

A small partial cutting made in an Engelmann spruce-alpine fir stand in 1924 now provides an opportunity to evaluate 30 years of growth on the residual stand. The stand is located in Spruce Creek drainage on the Kaniksu National Forest and occupies about 30 acres. It is part of a larger cutting involving 800 acres. The remainder of the area was cut on a group seed-tree basis. The original stand volume in the partially cut area averaged about 29,000 board feet per acre and the cutting removed 75 percent, principally in trees from the dominant and codominant crown classes. A little over 7,000 board feet per acre, chiefly Engelmann spruce, remained in the residual stand. Alpine fir was the principal associate with only minor quantities of other species represented. The age of the residual stand ranged from 118 to 140 years.

Despite the relatively small residual volume which was left, a reasonably good net growth was attained. The study shows that the Engelmann spruce made a net gain of 3,035 bd. ft. per acre in the 30-year period, 1924-1954, while the alpine fir sustained a net loss of 75 bd. ft. (table 7).

Table 7. Thirty-year gross and net growth and mortality per acre by species

Species	Reserve volume (1924)	1954 volume	Gross growth	Net growth	Annual mortality	Annual growth 30-yr. period Gross	Net
			Board	feet			
Engelmann spruce	5,906	8,941	4,255	3,035	[1]41	142	101
Alpine fir	1,095	1,020	729	-75	27	[2]24½	[2]-2½

[1] 3.2 trees per acre.

[2] Values in these columns have been rounded off to the nearest 1/2 board foot.

Deductions for defect were not made from the volumes shown in the table because this factor was unknown in the residual stand. However, defect as determined by borings in the 1954 measurements amounted to 6 percent of the 1954 volume in Engelmann spruce and 48 percent of the alpine fir. Heart rots were chiefly responsible for the defect. Some alpine fir trees were observed in which the rot had consumed the entire portion of the stem which was present in the residual stand and had made inroads into the inner portions of the growth laid on since logging. This large defect in the alpine fir further accentuates the disparity in the growth results between the two species shown in the table.

Mortality in the residual stand has not been unduly high considering the usual lack of windfirmness of Engelmann spruce. However, the stand was situated just under the crest of a ridge in a reasonably well-protected situation. The annual mortality of 41 board feet per acre of Engelmann spruce was caused primarily by windthrow, while much of the mortality in alpine fir appeared to be caused by sunscalding and windthrow.

Diameter growth of residual trees responded to logging release but there was no substantial response until the second 5-year period after logging (table 8). National Forest personnel reported no evident improvement in diameter growth after an examination of the cutting in 1929 which confirms the slow start. The growth response was striking in the second 5-year period and showed a gradual increase throughout the first 25 years after logging. Trees in an adjacent uncut stand showed some improvement in diameter growth over the same period presumably as a result of climatic factors.

However, the trees in the cut-over stand showed a considerably greater improvement and the difference between the two reflects the response attributable to release.

Trees were classified into three vigor groups based upon crown size, shape, and condition in the 1954 examination. The analysis showed that the growth of individual trees was related significantly to vigor.

Table 8. Average diameter growth of trees in residual stand and uncut stand in relation to time since cutting

	Five-year periods after logging					
	0-5	6-10	11-15	16-20	21-25	26-30
			Inches			
Residual trees	.35	.51	.61	.63	.67	.62
Trees in uncut stand	.36	.38	.47	.48	.48	.51

Water Percolation into the Soil Following Cutting and Slash Treatment

Percolation rates during the fourth year following cutting in the larch-fir type at Coram Experimental Forest in Montana still vary by surface condition. The greatest reduction in percolation rates is apparent on tractor skid roads where extreme compaction of the soil has taken place. Broadcast burned areas show little change in percolation from the year immediately following logging, while scarified areas show only a slight improvement. On undisturbed areas percolation was only about half as much as during the year following logging.

The values in the following tabulation show the amount of time it took for 1 inch of water to disappear in a 6-inch infiltrometer ring after a presoaking period of 5 minutes:

Soil surface	One year after cutting	Four years after cutting
Undisturbed	0 min. 60 sec.	2 min. 9 sec.
Scarified	6 min. 30 sec.	5 min. 12 sec.
Broadcast burned	1 min. 38 sec.	1 min. 47 sec.
Tractor skid road	24 min. 27 sec.	59 min. 18 sec.

INTERMEDIATE CUTTINGS

With the rapid depletion of virgin timber stands, the logging industry is looking with greater interest to second-growth stands for future raw materials. Information on managing this young timber will be needed and the Intermountain Station is attempting to extend a greater proportion of its research effort in this direction.

Addition to Boise Basin Experimental Forest

Because suitable stands of advanced second-growth ponderosa pine are not available on the present Boise Basin Experimental Forest, steps were taken this year to locate a tract of suitable timber land that could be added to the experimental forest for second-growth studies.

The Bear Run Unit was chosen because of its excellent stocking of young ponderosa pine, its easy accessibility from the Boise Basin Experimental Forest headquarters, its national forest status, and its relative freedom from mineral entry. On its 1,200 acres can be found a desirable range of age classes and sites.

Preliminary mapping has been completed and the application report written. Steps will be taken in 1956 to get formal approval for the addition of the Bear Run Unit to the Boise Basin Experimental Forest.

Commercial Thinnings on Woodlots in Second-Growth Ponderosa Pine

Farmers' woodlots play an important role in the timber production of the Inland Empire. In acreage, woodlots constitute nearly one-fourth of the commercial forest land area, but their importance is greater than acreage alone indicates. Being generally at lower elevations, the woodlots usually are suitable sites for ponderosa pine, one of the most valuable species in the area. Furthermore, because of early logging operations which were concentrated on easily accessible pine lands, a second-growth crop has developed which, in many areas, is now approaching commercial size.

Research in the management of second-growth ponderosa pine in the Inland Empire includes five sets of plots testing three degrees of commercial thinning for sawlog material in 90- to 100-year-old stands. The three treatments in each set of plots include (1) a control plot with no thinning, (2) a light thinning removing about 30 percent of the volume, and (3) a heavy thinning in which 75 to 80 percent of the volume was removed.

Results of the first 5-year remeasurement of one set of these plots indicate that the light thinning improved the quality of the growing stock without sacrificing total growth. Volume growth on the lightly thinned plot and the control plot were practically equal. Both of these plots nearly doubled the growth on the heavily thinned plot. Average annual growth on the control, lightly thinned, and heavily thinned plots were 400 board feet, 398 board feet, and 237 board feet per acre, respectively, for the 5 years following thinning (table 9). The light thinning provided an intermediate income through the removal of poor-vigor and poorly formed trees without reducing volume growth.

Table 9. Five-year growth per acre following commercial thinnings in second-growth ponderosa pine

Stand	Heavy thinning		Light thinning		No thinning	
	Trees	Volume	Trees	Volume	Trees	Volume
	No.	Bd. ft.	No.	Bd. ft.	No.	Bd. ft.
Before thinning	95.1	15,535	90.2	16,586	104.1	18,809
Removed	27.1	10,498	24.3	5,062	-	-
After thinning	68.0	5,037	65.9	11,524	104.1	18,809
5 years after thinning	65.5	6,221	63.1	13,516	99.2	20,810
5-year growth	-	1,184	-	1,992	-	2,001
Average annual growth	-	237	-	398	-	400
Total yield	-	16,719	-	18,578	-	20,810

Precommercial Thinning in Western White Pine Stands

Analysis of data from a dozen tests of thinning young white pine stands have revealed several consistent effects of thinning. The tests included a variety of types and degrees of thinnings on a wide range of sites, ages, and species composition. The earliest test was established in 1914; the most recent one in 1936. The following general conclusions apply generally throughout the tests:

1. Thinnings should be light; i.e., they should remove not more than 20 to 25 percent of the cubic-foot volume. Heavier thinnings generally result in excessive loss in volume growth.

2. All thinning treatments stimulated diameter growth of dominant and codominant trees. Generally, diameter growth was directly related to degree of thinning except that light repeated thinnings increased diameter growth more than a single heavy thinning.

3. Thinning white pine stands also improved the quality and value of the residual stands by increasing the proportion of high-value white pine.

4. Thinning failed to increase stand volume growth.

Commercial Thinning in Western White Pine

Tests of commercial thinnings in western white pine stands suggest, again, that cuttings should be light for satisfactory growth and yield. Five plots located on excellent sites have been under observation for periods ranging from 10 to 30 years.

Plot 111 is situated on the Priest River Experimental Forest in northern Idaho. At the time of cutting in 1925 the stand was 62 years old and had a volume of 18,557 bd. ft. per acre (table 10). Fifty-nine percent of the volume was white pine and 35 percent western larch. Other species present were Douglas-fir, grand fir, western hemlock, western redcedar, Engelmann spruce, lodgepole pine, and ponderosa pine. A heavy thinning from above removed 54 percent of the merchantable volume leaving a residual stand of 8,533 bd. ft. Basal area reduction was from 207 to 139 square feet, or 33 percent. Since no check plot was established for this plot, its development after cutting has been compared to normal stand development for similar site, age, and percent of normality. Such a comparison discloses that if the stand had not been thinned, the average annual growth would have been approximately 166 bd. ft. greater and that the total yield 30 years after cutting would have been 4,981 bd. ft. greater than it has been. Apparently this heavy thinning reduced the growing stock too much for maintenance of normal production from the site.

Table 10. Board-foot volume development per acre of Plot 111 as compared to the theoretical development of the same stand had it not been thinned

	Plot 111, cut	Normal development of similar uncut stands
	Bd. ft. (Scribner)	
Original stand	18,557	18,557
Thinnings	10,024	-
Residual stand	8,533	-
Stand in 1955	31,457	46,462
Mean annual growth	764	930
Total production	41,481	46,462

In contrast to Plot 111, two 70-year-old stands in the Bearpaw drainage of the Kaniksu National Forest on which only 25 percent of the volume and 20 percent of the basal area were removed came close to or surpassed the growth rates of similar uncut control stands. Plot 150, supporting a stand of 41,155 bd. ft. per acre was thinned in 1937 and has since had an average annual increment of 769 bd. ft. per acre as compared to check plot 186 which has grown 713 bd. ft. per acre per year in the period 1942 to 1952 (table 11).

On similar plots in the same area (Plots 188 and 189) the mean annual growth on the check plot was 83 bd. ft. per acre greater than on the cut plot (table 11).

Table 11. Board-foot volume development per acre of Bearpaw commercial thinning plots - Kaniksu National Forest

	Plot 150, thinned (15-year-record)	Plot 186, check (10-year-record)	Plot 189, thinned (10-year-record)	Plot 188, check (10-year-record)
		Bd. ft. (Scribner)		
Original stand	41,155	52,309	40,688	42,279
Thinnings	10,488	-	8,933	-
Residual stand	30,667	-	31,755	-
Stand 1952	42,195	59,444	36,932	48,290
Mean annual growth	769	713	518	601
Total production	52,683	59,444	45,865	48,290

Light commercial thinnings can improve composition, provide a current cash income, and through the construction of logging roads open the stand for management purposes. Other generally accepted advantages of light and frequent thinning which may become more apparent in these tests later in the rotation period are larger tree sizes on the thinned plots, better quality, and increased usable production by salvaging potential mortality.

OTHER ACTIVITIES

Boundaries of the Boise Basin Experimental Forest were posted this year against mineral entry in order to protect the research value and investment in the area. Action to afford the same protection to other study tracts is now under way.

The entire staff of the Boise Research Center joined the fire fighting crews of the Boise National Forest in September to help in the control of the disastrous Robie Creek fire. This center also cooperated with the California Station by collecting resin from 15 ponderosa pine trees on the Boise Basin Experimental Forest. The resin will be used by Dr. Mirov of the California Station in his extensive study of the chemistry of pine resins in the United States.

In this fiftieth year of the Forest Service, Forest Management Research publications by the Northern Rocky Mountain and Intermountain Forest and Range Experiment Stations were consolidated into an up-to-date list and published. The report (Miscellaneous Publication No. 6) includes releases by personnel in Forest Management Research at the two stations since the start of such work, publications by certain collaborators in this field, and selected material from other closely related divisions.

FOREST DISEASE RESEARCH

The program of Forest Disease Research at Intermountain Station was given a modest boost during 1955 by the financing of an additional position at the Inland Empire Research Center. The new man is to be assigned specifically to basic studies of white pine blister rust. One aspect of the investigation which will receive primary emphasis is the possible relationship of occurrence and spread of the disease to microclimate. The first phase of the project, now under way, consists of a problem analysis to be followed by the preparation of study plans by pathologists who have been working on pole blight and who know the forest type and the area.

Brief statements of progress in the effort to understand and learn how to control other major forest diseases of the Station area are presented in succeeding paragraphs of this report.

PONDEROSA PINE BLIGHT

Studies on the Elytroderma blight of ponderosa pine, which were initiated in central Idaho in 1948, were continued. During the past year added emphasis was placed on life history studies of the causal fungus, Elytroderma deformans, and possible methods of its control.

A number of small diseased pines (averaging 9 to 10 feet in height) growing on study plots have been under observation for the past five seasons. During that time progress of the fungus in the trees has been followed. Twigs and branches that were diseased in 1951, when the plots were established, have become reinfected annually since then. On the other hand, in these same trees the twigs and branches that were uninfected have remained free of the disease in practically all cases.

These findings suggest that some measure of control of the fungus may be obtained by pruning diseased branches. The experiment is being enlarged, therefore, to provide further information on this phase of the problem. Pruning could conceivably be done during the course of timber stand improvement operations that are conducted following logging in affected stands. In such stands that have been cut over and where timber stand improvement has been conducted it is not unusual to see pruned trees with but a few diseased branches remaining, all of which are within the lower portion of the crown. Removal of these branches at the time of the improvement operations would not add greatly to the cost of the work.

Another control experiment under way involves the application of fungicides. Work on this phase of the problem was started in 1954 when seven different materials were tested. Results obtained the first year were regarded as inconclusive and consequently the tests were repeated in 1955. Laboratory studies on the fungus, conducted for the purpose of checking the results of the current season's spraying, revealed that the pathogen failed to develop normally. Very few of the spores were found to have matured. For this reason the effectiveness of the fungicides could not be measured.

All evidence to date strongly indicates that environment is highly important in the development of the fungus. For one thing, it is an organism requiring relatively low temperatures, particularly for germination of the ascospores. About mid-July in 1955 when the fruiting bodies that produce these spores were in a tender stage of development, maximum daytime temperatures suddenly jumped 20° to 25° F. above maxima for about 2 weeks previously. It is believed that the fungus was unable to withstand this abrupt change in weather conditions, thus accounting for the failure of the ascospores to mature. Some degree of natural control of the pathogen may therefore have occurred.

In those affected stands where studies on the fungus have been under way since 1948, the intensity of tree infection in 1955 was at about the same level as that occurring since 1952 and considerably below the peak years of 1950 and 1951. Mortality on study plots during the current year was confined almost entirely to trees whose growth rate for the past 15 to 25 years, longer in some cases, has been very slow. In addition to slow growth rate other common characteristics of the trees that succumbed are fire scars and root decay.

POSTLOGGING MORTALITY IN PONDEROSA PINE

Mortality following logging in ponderosa pine stands causes losses that in some cases are very severe. Results of studies conducted to date in southern Idaho show that much of this loss is caused by the root rot fungus Fomes annosus. The fungus is present and is under observation throughout much of that part of the Station area in Forest Service Region 4 (Intermountain Region). The mortality problem is complex in nature and involves in part insect and disease interrelationships. Some of the other factors (not all pathological) which may be involved in the death of the pines are: (1) lightning, (2) opening up areas in the stand by heavy cutting and thus suddenly changing the tree's environment, (3) fire scars which provide ports of entry for decay fungi attacking both roots and trunk, (4) root injury and destruction caused by machinery used in building logging roads, (5) logging road construction on steep mountain sides requiring deep cuts that reduce tree vigor by altering the former drainage pattern which results in soil moisture losses, and (6) cutting off oxygen supply to the roots of those trees growing on the lower sides of roads by covering the roots too deeply with soil removed from the road cut.

POLE BLIGHT OF WESTERN WHITE PINE

Progress in studies of this serious disease by Intermountain Station during the past year may be summarized as follows:

1. A coordinated soils-pathological research program to determine the cause of the pole blight disease of western white pine has provided the most promising leads to date. Rootlet mortality, studied in 26 plots in healthy and pole-blighted white pine stands of the 60- to 80-year-age class, showed a significant correlation between the degree of rootlet deterioration and the severity of pole blight. Rootlet deterioration is also correlated with effective soil depth and the available water-holding capacity of soils, the latter soil factor showing the highest degree of correlation. The severity of pole blight, when expressed as a percentage of the total white pine basal area affected, is significantly correlated with the three factors--effective soil depth, available water-holding capacity, and rootlet mortality.

2. Intensive field examination of soils in the white pine type may aid in evaluating the pole blight disease potential. It appears that deep, well-developed, medium- to fine-textured soils capable of storing more than 6 inches of available water in the top 3 feet of soil favor the continuance of white pine stands in a healthy state. Shallow, rocky soils, or deep soils with a dense hardpan near the surface, present a restricted root zone, low available water-holding capacities, and are more commonly found to support severely pole blighted stands.

3. An experiment to determine the effects of an artificially induced moisture stress on healthy pole-sized white pine has been initiated. By means of a shelter constructed about the trees and the confinement of lateral roots within the plot, slow soil drying will be effected to determine if pole-blight-like symptoms may be produced. After one summer, the soil beneath the shelter is reflecting a decreased moisture content when compared to the control area.

4. Study of lesions associated with pole blight of western white pine culminated in a report published in Forest Science. It suggests that reduced radial growth is always associated with pole blight and precedes both crown decline and lesion development. A marked reduction in radial growth in the lower stem usually occurs before crown symptoms of the disease appear. Although lesions are generally associated with pole-blighted trees, they apparently are not directly responsible for the progressive decline of diseased trees.

5. The grafting work, undertaken to determine whether or not pole blight may be caused by a transmissible virus, has been transferred to the University of Idaho. All data and grafted material

were transferred to this cooperator to complement its work on this phase of pole-blight research.

6. A study of the root system of trees in healthy western white pine stands indicates that general root deterioration in the upper 1-foot of soil increases with increasing stand age. An incomplete analysis of data from twenty-seven 1-acre plots in stands ranging in age from 20 to 160 years suggests that in the 1 to 10 mm. diameter classes of root abundance and length per square foot of basal area decrease in the upper 1 foot of soil as stand age increases. Apparently, normal rootlet mortality does not vary greatly in healthy white pine stands from one age class to another.

7. Thinning dense stands of white pine or eradicating pole-blighted stems from diseased stands have not proved beneficial in halting the progress of pole blight. In comparing thinned and unthinned plots, pole-blight occurrence and damage is 2½ times greater in thinned plots. Three years after the removal of all diseased stems in another series of plots, pole blight continues to appear in the residual stand with a resulting reduction of healthy white pine volume.

8. Distribution surveys of pole blight during 1955 were limited to examinations of healthy stands near to and south of the southern limits of the disease. A suspected area, closely resembling pole blight, was found in the Clearwater National Forest in Independence Gulch about 6 miles north of the Kelly Creek Ranger Station. This area is outside the known range of pole blight. During the course of field work on other projects three new pole-blight areas were confirmed within the known range of pole blight.

9. The field work on damage appraisal surveys in pole-blighted stands has been completed. Surveys were conducted in four major diseased stands in 1955 which gives a total of 16 stands that have been sampled throughout the range of pole blight. Eight of these major stands are in old centers of damage and 8 are in recent damage centers. In addition to the major stands, 17 small newly affected areas were sampled for damage. Data from 12 of the 16 major diseased stands have been analyzed. For the 12 stands an average of 56 percent of white pine basal area is either affected or dead from pole blight with a range of 35 to 77 percent.

COMANDRA BLISTER RUST IN LODGEPOLE PINE

The Comandra Blister Rust is a fungus native to North America. It is known to attack several species of pines, including lodgepole pine. There is no record in the literature of the rust causing damage to the latter. False toadflax (Comandra umbellata) is the only known alternate host plant of the pathogen in the region. It has no forage value for livestock and big game animals.

Heavily infected lodgepole pine stands are now known to be present on six national forests in Region 4. In one stand it was estimated that 98 percent of the trees were diseased; estimates made in some other stands range between 65 percent and 85 percent. In all affected stands there is ample evidence that the fungus is intensifying at a fairly rapid rate and that damage is increasing.

Lodgepole pine has long been known to be a very occasional host of the rust. All evidence shows that intensification of the fungus in the affected stands is of relatively recent origin, i.e., about 15 to 20 years ago. The present behavior of the pathogen appears to be attributable to an increase on range lands of the toadflax. It is a plant not found in timber stands or in a good cover of grasses and appears in the succession when other plants die out. Its habitat is dry ground and rocky soils which usually have a low water content. Evidently there is more habitat area favorable for toadflax growth and spread today than there was some years ago. Furthermore, every heavy lodgepole pine infection area known is in association with range lands that have had long and heavy use.

No effective control methods are known at present. Tests of a number of herbicides for possible eradication of the alternate host plant are now under way on the Teton National Forest. Further disease research is needed for a more complete knowledge of the behavior of the fungus, particularly as it applies to damage to the pine, and to work out practical control methods. Closely allied studies should be undertaken to appraise present economic losses and possible future impacts of the disease, and to determine the importance of the pathogen as a factor in the management of lodgepole pine.

OTHER

The occurrence and buildup of the western gall rust (Cronartium coleosporioides) on ponderosa pine in part of the Lolo National Forest in Montana was reported in the Plant Disease Reporter. Intensification of this pathogen during the past 15 to 20 years has resulted in recent mortality and severe damage in limited centers in ponderosa pine stands along the Clark Fork River on the Lolo National Forest.

A new disease of eastern white pine was investigated and recorded for the first time in a plantation in the Northern Rocky Mountain region. The new root-stain disease in eastern white pine is caused by a fungus tentatively identified as a species of Leptographium, which invades the root system of host species causing a dark chocolate-colored stain of the sapwood. The stain progresses up the roots, past the root collar, and up the stem. Cambial death follows the stain in the xylem. Eventually the translocation system of the tree is girdled at or near the root collar. Tree mortality is quite rapid, almost coinciding with leader growth reduction and crown discoloration. The disease is potentially important in the West since lodgepole pine is also susceptible to it. The susceptibility of other conifers has not been determined.

Information on tree diseases and suggestions for control when known were provided to many forest users by staff pathologists. Contacts with National Forest administrative personnel were frequent and are resulting in a better understanding of the diseases prevalent in the forests of the Intermountain area. Cooperative help was extended to the National Park Service, to other agencies, and to schools.

FOREST INSECT RESEARCH

During 1955 the Division of Forest Insect Research went through a period of reorganization. It acquired a new Division Chief at the start of the year following the retirement of J. C. Evenden on December 31. The resignation of one entomologist, the transfer of another, and an increase in working funds posed a problem of staffing which was solved very satisfactorily. The group of entomologists located for many years at Coeur d'Alene was moved to Missoula, Montana and two entomologists from Ogden were stationed at the Research Center at Boise, Idaho.

With workers now stationed at Missoula, Boise, and Ogden, it is believed that problems of research, insect surveys, and technical advice on control projects in the Intermountain region can be handled much more effectively than before. In addition to the problems of staffing and relocation of field workers, a program of problem analyses has been under way to insure maximum use of personnel on the most important insect problems of the area. Active cooperation with all land managing agencies, Federal, state, and private, so essential to the program of the Division, has been strengthened during the year.

RESEARCH

It was realized that a thorough review of research needs in the area and the planning of future programs would require considerable time. Plans for 1955, therefore, were designed to carry on projects that had been under way for varying periods of time, while needs for change and new research were being considered. The majority of the research was performed at the Missoula laboratory, a good beginning was made on a research program at Boise for the southern Idaho area, and research was started in the Utah area from the headquarters at Ogden.

Engelmann Spruce Beetle

A program of research was started in 1952 in Montana and northern Idaho when a serious outbreak of Engelmann spruce beetles developed. Primary emphasis was placed on research directed toward the development of facts that would aid in control of the infestation. This work was continued in 1955. Considerable data on the habits of the species under conditions in Montana and northern Idaho have been gathered during the past 3 years.

This 1955 season the major attacks in green trees and trap logs occurred during the last week in June. Spruce beetle emergence from caged bole sections was observed in some instances at air temperatures of 38° to 40° F., but attacks occurred in green trees and logs during beetle flights when air temperatures rose to 70° F. It appeared that a very small portion of spruce beetle broods at higher altitudes required 3 years for complete development. The amount of woodpecker work on infested trees by the fall of 1955 was as great as might be expected in the spring of 1956 and this extensive feeding in the fall destroyed some parent adult beetles that normally might have escaped the feeding, and also destroyed young larval stages. The accelerated rate of woodpecker feeding may be important in reducing the epidemic. Attempts were made to measure the effectiveness of trap logs in connection with logging of infested trees as a means of control but results are not clear-cut. Measurement of their effectiveness is complex and difficult.

Inasmuch as the epidemic appears to be decreasing in intensity rather rapidly, it is planned that accumulated data be analyzed and a determination made of needs for future research on the species.

Tree Classification Based on Susceptibility to Pine Beetles

Plots were established in 1950 to test the effectiveness of the ponderosa pine risk rating system as a measurement of the relative susceptibility of ponderosa pine to attack by the western pine beetle in the northern Rocky Mountain region. The periodic pine tree mortality cruise on the study plots is scheduled for 1956.

Selective Logging to Control Pine Beetles

The work on this project is scheduled biannually on even numbered years.

Douglas-Fir Beetle

One of the program changes agreed upon during 1955 was that of centering the research on the Douglas-fir beetle at the Boise Research Center. The Missoula laboratory had conducted research on some phases during the past years. This material has been turned over to Boise. This season a survey of the Douglas-fir beetle situation was made in southern Idaho. Based on fairly complete knowledge of the area it will be possible to set up suitable study areas. Location of loss groups was provided by aerial observations and measurement of the diameters and numbers of Douglas-fir trees killed by the beetle in 1954 and 1955 was recorded. At the same time, possible causes of the damage were sought by observations. Such factors as logging, windthrow, and fire are easily recognized but were not present in the neighborhood of most loss groups. It was noted, however, that a great proportion of damage was located well up the sides of mountains and ridges. Information was gathered concerning the life of local outbreaks. It was noted during measurement of loss groups that most of the mortality had occurred rather recently. Current loss was searched for in a 2½-chain corridor adjacent to faded groups and it was often found that such loss was not present or only in reduced amounts. This situation needs exploring more fully to determine whether the beetles fly away from the groups or whether brood mortality accounts for the loss reduction. Collections of infested material were made to obtain information on natural enemies. Preliminary investigation of the possible interrelationship of spruce budworm damage and Douglas-fir beetle damage revealed that approximately 90 percent of the beetle-caused damage occurs in areas free of appreciable budworm damage at the present time. Based on the preliminary investigations this season, a work plan for 1956 is being developed.

Spruce Budworm

During the past few years limited studies on the biology of the spruce budworm have been carried on. During 1955 it was determined that a major study was needed and initial steps were taken to develop a problem analysis and work program. A review of literature was made. Entomologists at the PNW Station were consulted on biological techniques, progress of their studies, and suggested lines of study in the Intermountain region. Experimental plots previously established cooperatively with Potlatch Forests Inc., were reactivated.

Scattered field observations showed natural control possibilities. A parasitic fly, Pseudosarcophaga affinis, was abundant in several areas.

It is planned to complete the problem analysis and prepare work plans so the program can start in earnest in 1956.

Black Hills Beetle

Limited studies of the Black Hills beetle were conducted in southern Utah. The seasonal cycle of the beetle in this southern section of the area differs from that encountered in the more northern ponderosa pine areas. Cages were placed on infested trees to determine the seasonal emergence pattern. Comparisons made to determine if there were significant differences in the pattern because of elevational and exposure differences showed the variation between cages to be slight. There appeared to be substantially greater emergence from infested trees in the areas where the epidemic conditions had most recently developed. In closely controlled research experiments it appeared that an emulsion of ethylene dibromide containing 1½ pounds of EDB per 5 gallons of final mix would be satisfactory to control the Black Hills beetle. This is one-half of the strength ordinarily used. However, when used under conditions of application by control project personnel, the results were somewhat erratic. This is substantially in agreement with past experience; allowances must be made for less careful application in large-scale operations by less experienced personnel.

Puto sp.

A spruce mealybug (Puto sp.) has been known in the Engelmann spruce stands of southern Utah for some time. The infestation has spread and damage appears to be more severe than previously thought. A limited study in the area has been established to determine the extent of the infestation, significance of damage, and to gather such biological data as possible to determine if control might be desirable or possible. It was determined that about 60,000 acres of spruce are infested. Trees of all ages, including small reproduction, are affected and some quite severely. Biological data gathered to date indicate a possible 2-year cycle with both mature females and newly born young overwintering. Females are active on twigs from June until August when they return to the boles and hide under bark flakes. Living young were being produced by mature females in September. Stem analysis of infested trees indicate the heaviest concentration of mealybugs is at midbole. Future observations will determine more biological facts about the species including presence or absence of biological control factors.

White Fir Needle Miner

Defoliation by Epinotia meritana Hein., the white fir needle miner has been heavy in parts of Bryce Canyon National Park for some time. Damage along scenic highways in the Park and in adjoining commercial timber has been increasing. Results of trial and error tests in past years to control the species have been very erratic. This year a cooperative study with the National Park Service was started. It was felt that more should be known about the seasonal development of the insect in order to develop satisfactory control methods. An assistant employed by the National Park Service, following the plan developed cooperatively, made observations and collections during the season whereby the seasonal history of the species was determined. Data were collected on the degree of defoliation, needle miner population, and the number of needles mined per larva. Weekly collections of specimens were preserved for dissection to determine the presence of parasites. Limited tests with small hand equipment were performed using DDT, Dieldrin, Malathion, and Julius Hyman 269 formulations. Data have not been analyzed but it appears that DDT and Malathion may have promise.

Improvement of Insect Survey Methods

Research to improve both aerial and ground insect surveys has been strengthened. The needs for improvement are present in both detection and appraisal surveys. Field tests were made to develop more efficient airplane flight patterns to obtain better detection of current infestation symptoms and better coverage of forested areas. Descriptions of tree damage symptoms often confused with symptoms of insect damage are being prepared to aid aerial observers in classifying insect injury. Improvements were made and tested on aerial survey mapping facilities.

Tests were made to obtain beetle brood density measurements as a measure of the severity of infestations. It is believed that research into brood intensity and change can be utilized to increase value of appraisal surveys. Similar tests were started on spruce budworm.

It is planned to continue and expand these activities. A manual is being prepared on detection surveys for use by cooperators.

Cooperative Study - Boise Basin

A study by the Division of Timber Management of cutting methods at the Boise Basin Experimental Forest includes determination of mortality in the reserve stands. The Division of Forest Insect Research is cooperating. This season there was little activity on the part of the entomologists. A review is being made and upon agreement the cooperative features will be described and made part of the work plan to insure continuity.

INSECT SURVEYS

The Division of Forest Insect Research is responsible for detection and appraisal insect surveys. Increased detection survey coverage depends upon participation by cooperators in all land managing agencies, state services, and interested industrial and private land managers and owners. The past year has seen increased interest and participation in the insect survey program.

In the Intermountain region during the past season detection survey coverage has increased. In the northern portion of the region, over 18 million acres of forested land was surveyed by air and ground work and over 4 million acres of infestation by various insects was recorded. Most of the damage is being done by spruce budworm. In the southern portion of the region it is estimated that 15 million acres of forested land were surveyed by air and ground. The spruce budworm infestation of 547,000 acres in southern Idaho represents the greatest acreage of infestation this year.

Special mention might be made of new situations discovered during the season. On the Bridger Forest in western Wyoming a rather serious outbreak of Engelmann spruce beetle was revealed by aerial surveys. Prompt action by Timber Management in Region 4 has resulted in the sale of timber in the area. Logging of infested timber plus a limited trapping program is scheduled.

A total.of 44,100 acres of Douglas-fir tussock moth epidemic infestation in eastern Washington and Idaho was revealed by surveys. An examination of the infestation by research personnel has revealed a rather high degree of biological control and while plans are being formulated for chemical control it may be that analysis of data will show that it may not be needed. This is an example of need for increased attention to appraisals and close correlation with research.

Appraisal of the Engelmann spruce beetle outbreak in Montana and northern Idaho shows a decreasing intensity of infestation. Using 1952 as an index of 1.0, the trend in 1953 was 1.9, in 1954 was 1.6, and in 1955, 0.7.

A new outbreak of mountain pine beetle was discovered on the Teton National Forest. While it is not extensive, the concentration of infestation indicates that control is advisable.

An infestation of an undetermined defoliator was found on western larch over 33,000 acres in several forests in Region 1, 14,000 acres of lodgepole pine were defoliated by blackheaded budworm and lodgepole pine sawfly in Yellowstone National Park, and 3,400 acres of lodgepole were found to be infested by a needle miner in Montana.

TECHNICAL ADVICE ON CONTROL

The Division furnishes technical advice to all land managers and owners on insect control projects. The year 1955 was notable for the demands for this service in the Intermountain area. The entomologists assisted in planning control projects, recommended methods, materials, and timing, assisted in training project personnel, inspected operations, and judged results of projects.

The aerial spray projects in Idaho and Montana against the spruce budworm required the greatest effort. Nearly 1,200,000 acres were sprayed during July. The combined logging and trap tree program to control the outbreak of Engelmann spruce beetles in Montana and northern Idaho continued. The direct chemical control program against the Black Hills beetle on the Dixie National Forest and Bryce Canyon National Park was again active in 1955. Several minor control projects required technical services.

In addition to services on active control projects, entomologists participated in precontrol planning in the case of a combined logging and trap tree project on the Bridger National Forest where a serious outbreak of Engelmann spruce beetle was discovered in 1955. Activity will start early in 1956. An upsurge of Douglas-fir tussock moth in eastern Washington and northern Idaho resulted in planning for control in case biological observations being made indicate needs.

FOREST FIRE RESEARCH

The year 1955 was one of challenge, opportunity, and progress for forest fire research.

In parts of the West, hot, dry weather, searing winds, and a series of lightning storms combined to produce a critical fire situation. Seldom has it been more evident that protection of western forests must depend primarily upon the technical advancement of fire control science. The measures required to either prevent or control mass fire situations call for the best that science can produce. The 1955 fire season showed that measures not yet known or developed are needed for adequate protection of forest, range, and watershed resources, or in some cases, for the safeguarding of human lives. This is the challenge to fire research.

The year 1955 produced opportunity for fire research. Increased efforts on the part of cooperating agencies provided a greater opportunity to speed up work on existing projects and to tackle new problems. Activity by cooperating agencies in the fire-research program is at an all-time high.

Progress was made on three major research projects--fire-danger-rating, logging slash, and Project Skyfire. In each of these fields of work a major publication was issued in 1955. More important, 1955 saw the development for field use in fire-control operations of equipment and techniques which are products of these research projects.

FOREST FIRE LABORATORY

The forest fire laboratory organized at Missoula last year was developed further in 1955 mainly through the efforts of cooperating agencies. Donald Fuquay, research meteorologist of the Munitalp Foundation, was assigned to the laboratory staff on a full-time basis. DeVer Colson, research meteorologist of the Washington office of the Weather Bureau, was assigned to the laboratory for duty during the fire season. At the end of the year, plans were being made for the development of laboratory facilities needed in atmospheric, instrument, electronic, and fuel research in conjunction with the fire-danger-rating, logging slash, and lightning fire projects. These plans call for the temporary development of the most urgently needed facilities as a stopgap measure which will permit some progress in 1956 and the later development of more adequate laboratory facilities which are needed to insure continued progress.

The field arm of the laboratory is maintained at the Priest River Experimental Forest. These facilities received intensive use during 1955 on the fire-danger-rating, logging slash, and lightning fire projects. Priest River was the fire season headquarters for three scientists of the Munitalp Foundation and part time headquarters for all members of the Division of Fire Research. Others using the Priest River laboratory in 1955 included research workers from the University of Idaho, the University of Washington, and the U. S. Weather Bureau. Investigations have been started on the possible installation of research radar facilities at Gisborne Mountain lookout for use in Project Skyfire.

FIRE-DANGER RATING

Burning-Index Rating System

The year 1955 marked the development of a new and improved system of rating burning-index in Intermountain forests. The new system was adopted by forest protection agencies in Montana, Idaho, western Wyoming, northeastern Washington, Utah, and Nevada. The system is based on the following:

Mountaintop and Valley Bottom Fire-Danger Stations measure fuel moisture, wind velocity, relative humidity, temperature, precipitation, and lightning occurrence. These paired stations sample fire weather at two critical points in mountainous country. Burning-index between these two points is computed with a conversion table on the burning-index meter.

Model 8 burning-index meter evaluates four key fire-weather factors into one numerical scale.

Standard forms are used for recording fire-weather factors at all stations, for computing today's and tomorrow's burning-index and for plotting day-to-day changes in burning index. Lightning occurrence is also plotted at each station. These standard forms enable all agencies to gather and use comparable data, and are an aid in fire-danger-rating research. Records from some 300 fire-danger-rating stations now come to the Forest Fire Laboratory at Missoula.

Fire Behavior Evaluation Guides used in conjunction with burning-index ratings permit estimates of fire rate-of-spread according to variations in fuel types, topography, and time of day.

The new system of burning-index rating was featured at a fire weather training school conducted at the Missoula Smokejumper Center by the staff of the Forest Fire Laboratory and the Missoula and Boise fire-weather districts of the Weather Bureau. This training school was attended by personnel of forest protection agencies in Idaho, Montana, northeastern Washington, and western Wyoming. In 1956 additional training will be conducted for personnel in Utah and Nevada.

Model 8 Burning-Index Meter

The Intermountain Model 8 burning-index meter is the result of some 20 years of research. It is a direct product of the Model 7 meter which was given extensive field tests in 1954. As a result of these tests, a new model has been produced which is more sensitive to the wide range of fire-weather conditions of the Intermountain West than any meter heretofore used. The Model 8 burning-index meter has these features:

Severity index, or the cumulative effects of past weather, is evaluated from the 5-day total of fuel moisture as measured by 1/2-inch fuel moisture sticks. The 5-day 1/2-inch stick moisture provides an evaluation similar to that which can be obtained from measurement of the moisture content of large logs. The resulting severity index rating is an indication of the trend of the fire season. Day-to-day charting of severity index gives a numerical rating to the effect of drought or of many days of drying weather, or conversely, of many days of cool, wet weather. The effect of past weather is constantly brought up to date by the severity index system.

Current burning-index is computed by incorporating today's fuel moisture, relative humidity, and wind velocity with severity index. The Model 8 burning-index meter is thus sensitive to both past and immediate effects of key fire-weather factors. Given a low severity index and a high current burning-index, the result is only moderate fire danger. The combination of high severity index and high current burning-index would indicate a much more severe fire-danger situation.

The scale on the Model 8 meter has been designed so that interpretations may be described as follows:

Burning-Index	Fire Danger
1 - 20	Low
21 - 35	Moderate
36 - 50	Average
51 - 70	High
71 - 100	Extreme

Burning-index conversions from one time and place to another are computed by a slide rule device on the back of the meter. The conversion system is the result of extensive research of the hour-to-hour and day-to-day variations of burning-index factors on mountain slopes. Burning-index conversions can be made from valley bottom or mountaintop weather stations to north or south exposures on the lower third, the middle third, or upper third of mountain slopes. Under settled weather conditions, burning-index may be estimated for up to 8 hours from the time of measurement. Conversions of this type enable fire dispatchers and fire bosses to make reliable estimates of burning conditions at the site of a fire. They are also useful to forest managers in planning slash disposal and prescribed burning operations.

Burning-index predictions for tomorrow are computed on the basis of today's rating, tomorrow's weather forecast, and local experience in the trends of fire weather. The Model 8 meter contains a guide for estimating tomorrow's burning-index.

Large Log Study

Study of the moisture content of large logs exposed in various manners at the Priest River field laboratory continues to yield valuable information. Large logs may be visualized as a unique analog-computer capable of integrating the long range effects of drought and sunshine, precipitation and temperature, late spring and early fall, and many other factors of forest-fire danger. Analysis of large log moisture in relation to other factors has shown that general trends can be closely approximated by the 5-day totals of 1/2-inch fuel stick moisture. This discovery was a key factor in the development of the severity index rating used in the Model 8 burning-index meter. General results of the large log study were summarized in a paper entitled "How large dead forest fuels dry" which was presented by Charles E. Hardy at the annual meeting of the Northwest Scientific Association.

Fire-Danger-Rating Equipment

In the servicewide fire-danger-rating equipment development project under way at the Forest Fire Laboratory, the following progress was made in 1955:

A simple battery-powered wind counter was developed, field tested, and is ready for production. This wind counter records velocity in miles per hour over any given period. It enables average afternoon wind velocity, an important factor in fire-danger measurement, to be computed accurately. The instrument may be used in conjunction with any standard 60th mile contact anemometer.

A battery-powered fan psychrometer was designed and given preliminary field tests. This instrument should meet the need for a low-cost, reasonably accurate, device for measuring relative humidity at field stations.

A portable fire-danger station was designed and given preliminary field tests. The purpose of this station is to provide a lightweight fully portable unit for use on going fires, slash burning jobs, and other sites where temporary measurement of fire-weather factors is desirable. The present model weighs about 25 pounds and is compact for easy back packing. An alternate model will be designed for dropping by parachute from aircraft. The complete portable fire-danger station includes a lightweight shelter attached to pack board, a collapsible aluminum anemometer pole, an anemometer, a battery-powered wind counter and psychrometer, a rain gauge, maximum-minimum thermometers, fuel moisture sticks and scales, and a burning-index meter.

Two models of lightweight, aluminum instrument shelters were designed and given preliminary field tests. The purpose of these instrument shelters is to provide prefabricated knockdown units for use at lookout stations and other field locations where weather factors are measured only during spring, summer, or fall months, and then the instruments and shelter are removed for protection from severe winter weather. A key factor in the development of these lightweight knockdown shelters is the testing of aluminum as a suitable material for instrument housing. Preliminary tests of the heat reflection and absorption characteristics indicate that aluminum is a satisfactory material for shelters.

Recording Fire-Danger Station

Preliminary investigations were made of the possibility of developing a fire-danger station which would automatically record fuel moisture, wind velocity, and relative humidity. Such a station is needed at remote locations where weather measurement is important and manpower is limited. Development of a suitable fuel moisture recorder is the main technical problem in this project.

Fire-Danger Rating Operations

An 84-page illustrated publication, "Fire-weather and fire-danger station handbook" by Charles E. Hardy, Charles E. Syverson, and John H. Dieterich was issued. This handbook is a joint publication of the Weather Bureau and the Intermountain Station. It is now the standard guide for fire-weather and fire-danger station operations in the Intermountain West.

During 1955 the Forest Fire Laboratory continued to give technical assistance to forest protection agencies in the development of networks of fire-danger rating stations. In conjunction with the Weather Bureau, assistance was given in the training of personnel, and in the inspection of stations. An arrangement was developed this year for coordinated inspections by personnel of the Boise and

Missoula fire-weather districts and the Forest Fire Laboratory. Special attention was given to fire-weather and fire-danger rating problems in Utah, Nevada, and eastern Montana. The Bureau of Land Management, National Park Service, Indian Service, and Forest Service participated in the program.

Technical supervision was given to the manufacture of 2,200 sets of fuel moisture sticks at the Forest Service Spokane warehouse. Performance tests of these fuel moisture sticks were conducted at the Priest River field laboratory. Technical supervision also was given to the repair and calibration of fire-weather instruments received from all agencies. This work was performed at the Missoula Aerial Fire Depot. Wind tunnel tests of anemometers were made at the Forest Fire Laborabory.

PROJECT SKYFIRE

Project Skyfire is a broad cooperative program of lightning fire research aimed at (1) gaining basic information on lightning fires and storms, and (2) testing the possibilities of preventing or reducing the severity of lightning fires through cloud modification. The Munitalp Foundation, Inc., and the Intermountain Station are the principal backers of Project Skyfire. Dr. Vincent J. Schaefer, Director of Research for the Munitalp Foundation, Inc., is Co-Director of Project Skyfire. The United States Weather Bureau, the Universities of Washington, Idaho, and Montana, the Boeing Airplane Company, the General Electric Research Laboratory, the National Park Service, the California State Division of Forestry, Meteorology Research, Inc., the California Forest and Range Experiment Station, and the western regions of the Forest Service, all play important roles in the research program. Project Skyfire involves lightning fire research throughout the Western United States.

Cloud and Lightning Survey

The cloud and lightning survey was continued from a network of lookout stations in Wyoming, Montana, Idaho, Washington, Oregon, and California. Each day during the fire season the observers at these stations record the development, movement, and action of cumulus clouds, middle level clouds, and upper level clouds. At intervals during the day they measure cloud heights and speeds. When lightning occurs they attempt to count the number of strikes and map the area covered by the storm. Each day the observers transmit a special radio report giving a capsule summary of the cloud and lightning situation to the Skyfire staff at Priest River and Missoula. Later, when full reports are received from the lookouts by the Forest Fire Laboratory comprehensive regional cloud and lightning maps are prepared for each day of the fire season. These techniques are providing life cycle information on lightning storms which is needed in the development of lightning fire prevention and control programs.

Cloud measurement was made more accurate during 1955 through the development of a cloud theodolite. This instrument, fabricated from an aircraft compass and a gunsight, can be used as an aid in measuring cloud height, direction of movement, and cloud speeds. It is especially useful for estimating the speed of movement of high level clouds. A combination of cloud identification at upper and middle levels and cloud velocity measurements provides a means of tracking the jet stream in the survey network. The cloud theodolites were mounted on the catwalks of all Skyfire lookout stations during 1955.

A publication, "Project Skyfire cloud and lightning observation handbook" by Paul B. MacCready, Jr., Vincent J. Schaefer, John H. Dieterich, and J. S. Barrows was issued in 1955. This handbook is a general guide for all cloud and lightning survey activities. It outlines a system of cloud identification which is now in general use at many forest stations in addition to the Skyfire stations.

Time-lapse cloud photography with the special outfits provided by the Munitalp Foundation was continued at selected lookout stations. Tests were also made with special stereo cameras and a stereo analyzer to obtain quantitative data on cloud dimensions.

Lightning Storm Analysis

A major objective of Project Skyfire is to better understand lightning storm characteristics and to be able to identify the differences between storms. Key questions in this field include: Why are some storms dry and others wet? Why do some storms start few fires and others many fires? Why do some storms move slowly and others very fast? Can lightning storm types be predicted accurately? Can lightning storm types be recognized from cloud surveys?

In 1955 the Washington office of the Weather Bureau assigned research meteorologist DeVer Colson to Project Skyfire to assist in the lightning storm analysis program. Throughout the 1955 fire season Colson worked closely with Missoula fire-weather forecaster W. R. Krumm and members of the Skyfire staff on methods of identifying the basic characteristics of each storm. It is too early in the program to report conclusive results. However, preliminary observations indicate that there are at least three major storm types in the project area which are classified as air mass or local orographic type storms, frontal storms, and high level storms. The effect and location of the jet stream in relation to these storms is being studied.

Special Forecasts

Weather forecasting is an important factor in Project Skyfire. Daily weather forecasts including special analysis of the lightning situation are provided by W. R. Krumm, fire-weather forecaster of the U. S. Weather Bureau at Missoula. In addition, the Missoula fire-weather staff provides the Forest Fire Laboratory with daily maps of the jet stream, and with much other basic meteorological information. The flow of information works both ways. Reports from all Skyfire stations are transmitted by radio daily to the Missoula fire-weather office.

During 1955 the Severe Storm Forecasting Center of the Weather Bureau at Kansas City provided daily special forecasts and analyses for the Skyfire staff. These special forecasts concentrated on the jet stream and on instability patterns. They were watched especially closely in relation to fast-moving, high level lightning storms. The forecasts were found to be quite accurate and of great help to the Skyfire staff.

Long range forecasting is an important factor in lightning fire control. Under arrangements made by the Munitalp Foundation, Mr. Raymond Falconer of the General Electric Research Laboratory issued experimental long range forecasts for the 1955 fire season. The long range forecasting system developed by Falconer predicts temperature and precipitation 39 days in advance. These forecasts were issued weekly. They indicate the weather for each day of the forecast period. The science of long range forecasting involves many difficulties and unknowns and conclusive results are not yet available. This year the precipitation forecasts were 75 percent correct in July, 71 percent correct in August, and 72 percent correct in September.

Atmospheric Laboratory and Instrumentation

The mobile atmospheric research laboratory operated cooperatively by the Munitalp Foundation, the University of Washington, and the Forest Service was used in field studies throughout the 1955 fire season. At Priest River the laboratory made several 24-hour continuous runs measuring micrometeorological factors associated with lightning storms and with fire-climate on mountain slopes. The laboratory also provided data for use in conjunction with silver iodide generator tests at Missoula and Priest River.

Dr. Vincent J. Schaefer and Donald M. Fuquay of the Munitalp Foundation, developed a technique for use of the laboratory while in motion on mountain roads. Tests made on Gisborne Mountain at the Priest River Experimental Forest showed that the moving laboratory could be used to detect the presence of silver iodide concentrations at various positions on mountain slopes, and at various times. This is an important development which may be of assistance in the evaluation of cloud-seeding experiments in lightning prevention.

Development of instruments is an important phase of Project Skyfire. Late in 1955 preliminary work was started on the development of a lightning counter for use at lookout stations. This will be an electronic instrument which records each lightning stroke within a given distance of the observing station. The instrument will fill a vital need in lightning storm analysis. Preliminary studies show that such an instrument can be developed at rather low cost. Principal bottleneck in the development program is lack of suitable laboratory facilities and instruments for testing and calibration of the unit.

Investigations are being made on the possible use of radar as an aid in lightning storm tracking and analysis. Available information indicates that radar can be a very important tool in lightning fire research, and that eventually radar may become part of the standard equipment at a few key lookout stations. The Project Skyfire staff are looking into possible cooperative arrangements for radar with the Air Defense Command and with the Weather Bureau. A modified radar especially designed for lightning detection is most desirable and would probably produce the best results.

Experimental Meteorology

A key question in cloud-seeding operations of the type which might be used in lightning reduction, is the feasibility of using silver iodide ground generators. Under the auspices of the Advisory Committee on Weather Control a series of experiments aimed at this question were performed in the Missoula vicinity. These experiments were carried out by Meteorology Research, Inc., of Pasadena, California, under the direction of Dr. Paul B. MacCready, Jr., and with the assistance of the Forest Service and the Munitalp Foundation. The base of operations was the Smokejumper Center at Missoula. The experiments involved the use of a glider equipped with a portable cold box to collect and test air samples over an area where silver iodide generators were operating. This is an important new technique for determining the location and the effectiveness of silver iodide nuclei. The glider provides an excellent means of collecting air samples because it climbs in the same thermals where silver iodide is likely to be found, and the glider does not introduce exhaust fumes into the sample. The glider is towed from the airfield with a power plane and then cut loose.

The tests showed that silver iodide crystals were found up to 4,000 feet above the generators and up to a maximum horizontal distance of 15 miles. With the type of generators used it is concluded that satisfactory concentrations of silver iodide nuclei will reach clouds in the summer months.

Program Review

Under arrangements made by the Munitalp Foundation, Dr. Herbert Riehl, of the University of Chicago, visited Project Skyfire field operations for the purpose of reviewing the entire research program and of making recommendations for future activities. Dr. Riehl was given a general briefing of the entire program and visited several field stations and the Forest Fire Laboratory. Upon conclusion of his visit he prepared a report setting forth many helpful suggestions for future research.

Advisory Committee on Weather Control

Captain H. T. Orville, Chairman of the President's Advisory Committee on Weather Control, and nine members of the committee reviewed Project Skyfire field operations during the 1955 fire season. The committee examined Skyfire activities as one phase of their over-all job of making recommendations for a national policy and program on weather control research and operations. Lightning fire prevention and control is an important segment of the national problem.

LOGGING SLASH RESEARCH

Logging slash research is carried out in cooperation with several state, private, and Federal agencies. Principal contributor to the project, along with the Intermountain Station, is the Forest, Wildlife, and Range Experiment Station of the College of Forestry, University of Idaho. Also assisting in the project are the University of Washington, the Munitalp Foundation, the California Forest and Range Experiment Station, and National Forest Administration. In 1955 a major progress report, "Logging slash--A study of the problem in Inland Empire Forests," by D. S. Olson and George R. Fahnestock, was issued as Bulletin No. 1 of the University of Idaho.

Experimental Burning

During 1955 the first major phase of the experimental burning program to study slash flammability was completed. Collections of slash of the nine commercially important tree species of the northern Rocky Mountains have been burned both during the year of cutting and 1 year after cutting. During the period 1952-1955, 173 plots of lopped slash and 48 plots of chipped slash have been burned. Rate-of-spread records have been kept on each plot, and heat radiation records on all of the lopped slash plots with a very few exceptions. The stage is set for detailed analysis of all results obtained thus far.

In late August and September 63 plots were recharged with lopped slash of all nine species at the three weights per acre used throughout the experiments. Burning will be carried on again in 1960 to determine the effect of aging 5 years on flammability. Interim records will be kept of compaction and apparent physical changes.

Near-perfect weather during August 1955 permitted expeditious burning of 60 plots. On 48 plots, 1-year-old slash of ponderosa pine, lodgepole pine, western larch, and grand fir was burned. As noted for the five other species, aging 1 year appeared to reduce fire rate of spread significantly. Fires in the two species of pine slash showed the least reduction of all the species in both rate of spread and heat intensity. To clear up the question of comparability of heat radiation data between years, on several plots radiation was measured simultaneously with the three radiometers (black-ball, Gier and Dunkle directional, and Beckman-Whitely flat-plate) used in the course of the study. Gasses were collected from the convection column of one fire to be analyzed as a check on the completeness of combustion. Dr. Konrad Buettner, of the University of Washington, gave valuable service in the determination of fire temperature, radiation intensity, and heat budget.

The other 12 plots were holdovers of 3-year-old western white pine, western redcedar, Douglas-fir, and western hemlock slash which early rains had prevented burning in 1953. Records from these plots will provide information on the effect of age between the first and the fifth year after cutting.

Slash Measurement

Weight per acre.--Results of experimental burning show that quantity, expressed as tons per acre, dry weight, is the critical factor affecting flammability of the current year's slash. Our own studies and those of the California Forest and Range Experiment Station have developed a method of calculating crown weight, hence, expected weight of slash, for individual trees from measurements of d.b.h. and crown length. In 1955 a start was made on putting weight calculations on an acre basis. Detailed crown measurements and descriptions were recorded for every tree on one 1/2-acre permanent sample plot. Crown lengths of representative trees were measured on additional plots. Summation of the calculated weights of all tree crowns on a plot will provide the best available approximation of potential slash weight per unit of area. Thus a start has been made toward ultimate preparation of slash "yield tables" which will show with acceptable accuracy the weight per acre of slash per thousand board feet that can be expected to result from cutting in each forest type as modified by age, site, and stand density. This knowledge will make possible realistic appraisal of the expected slash disposal job on any area before the timber is cut.

Classification and Measurement of Slash Components.--Compactness and surface-area-to-volume ratio are two important factors affecting combustion rate. Annual measurement of slash depth on the experimental burning plots is providing information on compactness in relation to species, age, and weight per acre. Some information on the area-to-volume ratio has been obtained by determining the weight, and calculating the volume and surface area of material of different diameter classes in branches of several species. For the few branches that were dissected, needles were found to comprise roughly 20 to 50 percent of the total ovendry weight, the percentage increasing in proportion to the tolerance of the species. Douglas-fir, on which the most complete analysis was made, had 35 percent of its weight and 80 percent of its surface area in needles. The approximate surface area per pound of Douglas-fir slash was found to be 25 square feet.

The value of classifying and measuring slash components includes many possible applications in forest management and protection. One use in the field of fire control is to establish comparability of different fuels on a measured or mathematical basis. Branch analysis carried on in conjunction with experimental burning of the same type of material should lead to a much better understanding of rate-of-spread and radiation differences. To provide more certain information and permit better evaluation of possible uses, additional branches were collected in the fall of 1955 for subsequent analysis.

Slash Disposal Methods

Partly as a result of encouragement by the Station, the St. Joe National Forest bought a portable chipper in 1955. Preliminary arrangements have been made for a cooperative study of comparative costs and accomplishments of disposal by chipping and by hand piling and burning.

ALASKA FIRE RESEARCH

In September, at the invitation of the Bureau of Land Management, Jack Barrows visited Alaska for the purpose of investigating the fire control problem in the interior forests and fire research needs. Working in cooperation with Bureau of Land Management foresters, Barrows paid special attention to the requirements for early development of a fire-danger rating system. Technical assistance will be given to the Bureau of Land Management in the development of a few key fire-danger stations and experimental use of the Intermountain burning-index rating system. Interior Alaska has some 225 million acres requiring fire protection. Lightning and man-caused fires are causing an annual burn varying from 1-1/2 to 4-1/2 million acres. The territory provides a virgin opportunity for fire research and the technical advancement of fire control.

NATIONAL FIRE RESEARCH CONFERENCE

The Intermountain Station was host to a national fire research conference held at the Missoula Smokejumper Center, October 24-28. Attendance included all of the professional fire research technicians of the Forest Service, two station directors, several regional fire chiefs, equipment development technicians, and three members of the Weather Bureau. This was the first national fire research conference since the meeting held at Priest River in December 1941.

FOREST ECONOMICS RESEARCH

The Division of Forest Economics Research has been assigned reponsibility for the forest survey and economic studies in the 9 Mountain States: Montana, Idaho, Nevada, Utah, New Mexico, Arizona, Colorado, Wyoming, and South Dakota. The past year has been spent largely in replanning our program to fit this enlarged area.

FOREST SURVEY

Survey Plans and Techniques

A tentative plan for the forest inventory of the Rocky Mountain States was prepared early in 1949. Because of the many changes taking place during the past 6 years it has become necessary to revise this original plan. Work on the revision was started this year. Information gathered in connection with the recent Timber Resource Review gives a much better basis on which to plan than was available in 1949. As a further aid in preparing an up-to-date plan a critical look was taken at methods of making sample surveys. Four different sampling techniques for determining forest area were studied. These included line sampling, block sampling, strip sampling, and dot sampling. Aerial photographs were basic to all of these. To round out the story, strip sampling without photographs was also studied. Cost per acre of commercial forest land varied from 0.80 cent to 1.26 cents assuming that suitable aerial photos are available and only prints need be purchased. When new photography must be taken the costs varied from 2.23 cents to 2.72 cents per commercial forest land acre. The difference in cost for the different methods is not great, so major consideration can be given to the needs of the customer and amount of cooperation available when selecting the method to use.

To further improve our method of operation we made a complete conversion of the compilation phase to the International Business Machine system. A coding scheme was set up in cooperation with the California Forest and Range Experiment Station, and arrangements were completed whereby this station will provide us with the tabulations we need.

In cooperation with the California Station a brief test was made of the use of "mark sense" cards for recording inventory plot data in the field. As a result of this test we found that use of these cards required too much additional time on the plots; therefore we cannot use them on the Forest Survey. This system should be quite acceptable for use on plot inventories involving collection of less information than on the Forest Survey.

Aerial Photo Interpretation

During 1955 the program on photo interpretation research gained momentum with the initiation of several studies. These were concerned largely with questions of photo dot sampling in areas of rough terrain such as encountered in the Rocky Mountain area. Studies completed or under way include:

1. The relation of size of minimum area to the proportion of forest and sawtimber acreage obtained by dot sampling on aerial photos. This study is nearly complete.

2. Significance of image displacement and scale difference due to relief when sampling on aerial photographs. This study is in the compilation stage.

3. The accuracy of stand height measurements on aerial photos in the Rocky Mountains. This study has been completed and results have been published. Because height correlates well with volume, stand height is one of the most useful measurements foresters can make on aerial photos. The results of this study indicate that stand height measurements made on aerial photos compare very favorably with average stand heights derived from a few Abney readings made in the field. It is also pointed out that when corrections are made for elevation, height measurements made in areas of rough terrain are just as precise as those made in areas of more gentle terrain.

As a still further attempt to make fuller use of aerial photos we are working on the construction of aerial volume tables for conifers in the Rocky Mountains. Photo measurements have been completed for some 200 forest survey field plots. These photo measurements will be correlated with field-measured volumes to produce alignment charts giving average cubic- and board-foot volumes for various photo measurements.

An essential to successful use of aerial photos is well trained interpreters. After the interpreter is acquainted with the fundamentals he must become familiar with the terrain, cover, and species of the country in which he will be working. He is not always able to spend a lot of time in the field, so as an aid in training and making interpretations we have prepared 18 stereograms consisting of vertical aerial photos and horizontal ground stereo photos of conditions common to the White River and Arapaho forests of Colorado. Included with these stereograms are photo measurements of height, crown size, and stand density, and a narrative description of the stand. Also in connection with training, 12 basic problems in resource interpretation were designed along with interpretation aids to be used by the field crews.

Initial Inventory

Field work was concentrated in southern Idaho until August 1. About 1,712,000 acres of forest land were sampled. This brings the total forest area in south Idaho to 10,800,000 acres and completes the field phase of the survey job in this State. Compilation work was carried on throughout the season, and was concentrated at the California Station where the IBM installation is located. As of the end of the year about 80 percent of the total job was finished. A statistical report will be prepared and released during 1956.

Final plans were made for a cooperative survey with Region 2 of the Forest Service of a major portion of the commercial forest land in Colorado. Work has been started on photo interpretation for a complete cover map within the national forests. Field work in the spruce bark beetle-killed area was carried on by a 5-man crew during the summer. Contracts for new aerial photography for about 13,500 square miles were awarded by Region 2, in connection with this joint project. Some of this photography is being delivered now. Next year will see a concentration of field work in Colorado.

Maintenance Inventory

The maintenance survey was continued in Lincoln, Sanders, and Mineral Counties in western Montana. About 1,175,000 acres of forest land were sampled. Mineral County is now complete with minor portions of the other two counties left to do. Nearly 18 percent of the forest land in Montana has been reinventoried to date. If suitable aerial photography becomes available we should complete the field work in these three counties in 1956 and prepare a statistical report showing area of forest land and timber volumes.

Timber Cut

Early in 1955 a canvass was made of wood-using industries in Montana and Idaho to determine the amount of timber removed from the woods for the various wood products. The purpose of the data is to keep survey statistics up to date. Release of the information awaits correlation with Bureau of the Census data from its Census of Manufacturers in 1954. A publication will be issued early in 1956.

Our annual surveys of pole production in the northern Rocky Mountain region, and shipment of Christmas trees from Montana, were made. A survey to determine the pulpwood production in Idaho and Montana during 1954 was also made.

During 1954 Montana's Christmas tree shipments reached a record high. More than 3.4 million Christmas trees were shipped from the State. Flathead and Lincoln Counties continued as the leading producers. Missoula County made rapid strides towards overtaking the leaders. Texas, Iowa, Missouri, and Oklahoma were the largest markets for Montana's trees, receiving nearly 42 percent of the trees shipped from the State.

Pulpwood production in north Idaho and Montana dropped about 87 thousand cords below 1952 production. This is 38 percent less than that year. Total production in Idaho and Montana was slightly more than 148 thousand cords. Pulpwood production increased in north Idaho and western Montana but the increase failed to compensate for a drop of more than 92 thousand cords in shipments from eastern Montana to mills in the Lake States.

The number of poles produced within the northern Rocky Mountain area in 1954 was 34 percent of total production during the peak year of 1947 and 67 percent of 1953 production. The following table shows the number of poles produced in 1954 by species and location:

Species	Montana	North Idaho	Northeast Washington	Total	Percent of total
Western redcedar	3,092	126,035	9,497	138,624	49.8
Lodgepole pine	101,842	0	0	101,842	36.6
Western larch	31,829	5,075	34	36,938	13.3
Douglas-fir	768	0	0	768	0.3
Total	137,531	131,110	9,531	278,172	
Percent	49.5	47.1	3.4		100.0

ECONOMIC STUDIES

As a first step in developing an economics research program for our enlarged territory we made a general analysis of the needs and opportunities for economic studies in the Mountain States. This analysis was published as a Station paper under the title, "Economics research needs related to wild land management and development in the Mountain States." In addition to suggesting types of economics studies which would facilitate management and development of the wild land resources in these states the report makes seven major points:

> Wild lands are geographically and economically dominant. Wild land resources are important in every region and no region can survive without them. Nevertheless, it is fair to say that the forests and rangelands of the Mountain States are closer to the life and welfare of the people in these states than is probably the case in any other region.

Other states have a direct and vital interest in the wild land management of the mountain region because this region supplies much of their water.

Much of the land is publicly owned; thus the public has an especially great responsibility for developing sound policies and programs for the use and management of wild land resources in the region.

The physical margins are narrow; thus the resilience of the Mountain States as an environment is low, and the land resource is particularly susceptible to damage from overuse or misuse.

The economic margins also are narrow insofar as return to the land is concerned.

Multiple use and integrated use are particularly urgent in the Mountain States.

We are still in the formative stages of resource development; so both the responsibility and opportunity for sound planning are doubly great.

During the year we undertook a study of the timber industry opportunities in the Idaho Falls, Idaho area and the Kemmerer-Green River, Wyoming area. This project was undertaken at the request of Region 4, Forest Service. That office and the 8 national forests involved have helped in various phases of the work. The study will be completed and a report issued in 1956.

Like the timber in many other parts of the Rocky Mountains, the stands tributary to Idaho Falls, Kemmerer, and Green River are underdeveloped. Some small sawmills, tie mills, and pole producers have cut from these forests for half a century or more, and during the past few years lodgepole pine from the Targhee National Forest has been shipped to pulp mills in Wisconsin. Nevertheless, all of these operations have utilized but part of the timber-growing capacity of the locality and in some cases they have not used it particularly well. Several factors have contributed to this situation: The economic isolation of the region marketwise, long hauling distances from woods to railroad, relatively low volumes per acre, rough topography, and the absence of "gold-plated" species such as white pine and ponderosa pine.

The recent growing interest of industries in Rocky Mountain timber has revived hopes of considerably greater development in this locality. There has been much discussion of the possibility of acquiring a pulp mill or two, medium size sawmills, and hardboard mills. The location here of any such plants would certainly be desirable from the standpoint of local employment. It would also open up new timber supplies to the Nation and would round out the local economic picture. Expansion of the timber industries is likewise a must if there is to be good forest management in this area. Lack of markets for overmature timber which has suffered recurrent attacks from insects and diseases makes it difficult, and in a few cases futile, to protect the timber. Because of the inadequacies of the markets, utilization has been incomplete on many areas logged in the past. Residual tree growth that should have been removed has in some cases made it hard to regenerate new stands following logging or created other problems.

A careful analysis of the area and its probable opportunities will be especially helpful to new industries seeking to locate here. Furthermore, there is an unusual opportunity to develop the timber resource of this locality in a planwise manner because practically all of the timber is in the national forests and most of the development lies ahead.

The study has undertaken to answer five general questions:

1. How much timber industry can the forests of this area support?

2. How far is the timber industry likely to be able to go in utilizing the forest resource of the area?

3. What types of industrial development are most feasible and desirable in each of the areas?

4. Where should the industrial plants be located?

5. What present action will best facilitate any long-run objectives of timber industry development?

RELATED PROJECTS

During 1955 S. Blair Hutchison who has been participating in the over-all analysis phases of the Timber Resource Review for several years completed his assignment. He was co-author of Chapter VII of the Timber Resource Review, "Future timber supply and quality of domestic timber."

As a result of Harry W. Camp's assignment to Iran, Mr. Ziaedin M. Roshdieh of the Iranian Forest Service was assigned to the Station during the field season. Mr. Roshdieh was given practical training in forest survey techniques and consulted with members of the staff in regards to practices that could be applied to the forests of Iran.

Early in 1955 Mr. J. O. Lammi left the Station and joined the staff of the United Nations at Geneva, Switzerland as forest economist.

FOREST UTILIZATION RESEARCH

The activities of the Division of Forest Utilization Research were highlighted in 1955 by the retirement of I. V. Anderson, who completed 35 years of service, most of it in utilization work. The mid-year retirement of Anderson and delayed appointment of a successor has caused some interruptions in the program of activities in the division. There was no reduction, however, in the importance or urgency of this work.

Utilization research is an essential component in the complete development of forestry activities throughout the Intermountain and Rocky Mountain regions. As pressure for timber increases in the better established areas, and as development increases in the more remote areas, there is a constant need for research and guidance to timberland managers and forest industry operators. This is an era of technological change. New methods of logging and harvesting, new methods of log preparation, new methods of milling and manufacture, and new concepts of marketing are keeping the forest industries in a constantly changing situation. Only those industries which are willing and able to apply the most modern techniques find themselves in a truly sound position. The Division of Forest Utilization Research is charged with the dual responsibility of seeing that the research needs of the regional forest industries are met and that the results of the research are put into action with the minimum amount of delay. Some of the more important accomplishments along these lines are enumerated below.

TIMBER CONVERSION

It is estimated that as much as one-third of the remaining timber of the Intermountain and Rocky Mountain regions grows on steep mountainous slopes considered inaccessible or inoperable by many logging methods. As the demand for timber grows and as more of our forest lands are brought into operation, it is essential that these high altitude forests be made operable. Experiments in overhead cable logging on some of these mountain slopes has helped to demonstrate that these lands can be harvested in harmony with other mountain forest uses. Through the efforts of the division, a demonstration of a Swiss overhead cable logging system was installed at Turner Flats on the St. Joe River to log blister-rust infected western white pine from an overmature stand. Earlier logging in this same area had bypassed many of these steep sites where slopes run up to 165 percent. After nearly a year's operation the Swiss crew have demonstrated that these areas can be logged profitably.

Completion of earlier studies of the effect of time on the deterioration of bug-killed Engelmann spruce sawtimber showed that the yield of acceptable lumber was satisfactory and that there was only moderate degrade 2 years after mortality. Although some degrade and dollar loss was expected, it is significant that material which has fallen prey to the epidemic ravages of insects is still of a salvageable character. Information such as this makes it possible for forest land managers to continue and accelerate their harvest of dead material.

TIMBER GROWTH AND UTILIZATION RELATIONSHIPS

One of the prime considerations in growing timber is to grow it for a specific use. The ultimate goal, perhaps, in forest management is timber tailormade for a specific end-use. A cooperative study was undertaken with the objective of growing trees specifically for telephone and transmission poles. Western larch is a highly desirable species for this use and a study was established in which the growth rate, sapwood thickness, grain spirality, and other genetic factors as well as the effect of cultural measures will be studied in an effort to produce a maximum yield of the most desirable pole material in the minimum amount of time. This is only the first of such a series of studies that will be developed for a multitude of products.

PULP AND PAPER

It is an established fact that decay influences the amount of pulp yield from wood. Western hemlock, which grows rather abundantly in portions of the Inland Empire, is a desirable pulpwood species frequently left unused because of extensive decay. There has been a general reluctance on the part of pulpwood buyers to utilize this material for fear of low yields because of the high decay. A cooperative study has been undertaken to measure the influence of varying degrees of defect on the yield of hemlock pulp. Chips from logs of four degrees of decay will be pulped by various chemical and mechanical methods and the yields evaluated. The significance of the results of a study such as this is obvious. If it is found that at certain levels defect plays a less significant role than was previously anticipated, a considerable volume of western hemlock will find its way into pulpwood uses.

PHYSICS AND ENGINEERING

Telephone and transmission poles must be adequately seasoned to give satisfactory performance and to be properly treated with wood preservatives. Little is known about the seasoning characteristics of many of the commercial pole species. A study was undertaken this year to determine the air seasoning cycles for western larch poles. Information to date indicates that it takes so long to air-dry larch poles, especially of the larger sizes, that other means of seasoning should be explored. Perhaps the answer lies in a dry kiln of some design suitable for transmission and telephone poles.

Poles are an engineering material and their use follows specific design criteria. As part of a nationwide testing program conducted by the American Society of Testing Materials, western redcedar, lodgepole pine, and western larch poles were selected from the Rocky Mountain and Intermountain regions for strength evaluation. The results of this study are not yet published but indications are that strength values are comparable to the earlier estimates made in previous studies.

WOOD PRESERVATION

The natural durability of western larch has been studied, but a supplementary study of material from trees 160 to 200 years old was initiated to further document the information now available on natural durability. Since western larch is a thin sapwood tree when grown in many places, it is important to understand the natural durability of the heartwood.

PROGRAM ORIENTATION

These highlights of experiments and studies conducted during 1955 tend to illustrate the general activity and role of Forest Utilization Research of the Intermountain Station. There were, of course, many other contributions to the whole field of study, encompassing broader and more complete utilization of the forest resource. Accomplishments of industry, of forest management research, and of land management agencies in extending and broadening the usefulness of the various species, the more complete utilization of plant and woods residues, and the inauguration of new industries could be mentioned and discussed. Continuation of the general program and specific projects in the next year goes without saying.

As the result of the enlargement of the area of work of Forest Utilization, and the change in personnel, there may be some shifts in emphasis both as to geography and specific problems. There is an urgent need, for example, for work in southern Idaho and Utah in assisting operators, many of them newly established but with great ambitions, in getting the maximum benefits from their forest resources. There are definite indications that the feasibility and opportunities for pulp and paper development throughout the entire Intermountain region are reaching a new peak of attractiveness, and efforts must be made to familiarize possible operators and investors with the opportunities that exist. Intensive surveys to demonstrate and illustrate these pulp chances are under way. There is an ever-increasing need on the part of forest land managers, particularly National Forest Resource Management, to establish better and more objective criteria for the evaluation of logs for lumber, veneer, and other products.

As the competition for timber resources becomes increasingly more active and pointed it is essential that timberland appraisals become more definitive. Studies of this sort are scheduled and will be undertaken as the opportunities arise. There is increasing activity in the production of veneer and plywood from Intermountain and Rocky Mountain species. There is increasing activity in establishing and developing particle board operations following the ascending national trend in such products. There is always a great need for improvement and cost reduction in logging, log transportation, and log preparation.

Geographically, the work in Forest Utilization Research can be divided among the Inland Empire, the Northern Rocky Mountain area, and the Intermountain region. Emphasis in the past has been predominantly in the two northern areas, but the future will find increasing activity and opportunity in all three areas. Within the modest limitations of the existing unit, efforts will be made to serve all three areas with equal zeal.

RANGE MANAGEMENT RESEARCH

BIG-GAME WINTER RANGE REVEGETATION

Planting Bitterbrush in Idaho

The big-game winter range revegetation studies conducted cooperatively with the Idaho Fish and Game Department on the Payette and Boise River drainages in southwestern Idaho are mainly concerned with planting techniques for bitterbrush.

Seeding depth.--A depth-of-seeding study showed that with an increase in seeding depth--which may be desirable in that it delays emergence and could thereby minimize seedling loss from frost heaving in early spring--there is an associated decrease in percentage success of emergence. Successful emergence means, in this case, one or more seedlings emerged, regardless of the number of seeds planted in the seed spot. With an increase in number of seeds per spot, for depths between 3/4 and 2-3/4 inches, percentage success of spots is increased, and, of course, the average number of seedlings per spot from a particular depth is likewise increased. With only one season's results at hand, it seems that about 4 to 8 seeds planted at 1-1/4 inches would give satisfactory results, with as much delay in emergence date as can be attained without great sacrifice of success of seed spots. Another planting of this study was made in the fall of 1955.

Mortality of seedlings.--Of the bitterbrush seedlings that emerged in the aforementioned study, 34 percent died during their first growing season. Nearly half of the mortality was attributed to damping-off, which occurred in early spring. The spring season of 1955 was unusually cool and moist, and seedling loss from damping-off seemed more common than in other years. The causative organism is not known. Another one-third of the mortality appeared to be the effect of drought, and occurred in late summer. Insects (moth larvae) accounted for less than 10 percent of the mortality, and loss from this cause was mostly in early spring. Grasshoppers were relatively few on the Payette and Boise deer winter ranges in 1955 and, although these insects are known to be able to wipe out stands of first-season bitterbrush, none of the 1955 seedlings under observation appeared to have been disturbed by grasshoppers.

There was some mortality for which no cause was apparent. Frost heaving, which in past years has been an important factor in bitterbrush seedling mortality, was not a factor in 1955.

Effect of game.--On ranges already overstocked with game animals, there is little likelihood that much artificially seeded bitterbrush can become established. Data gathered in 1955 showed many small plants to have been broken or trampled out by deer in winter or early spring, and almost all plants observed in this study had been severely browsed. In one series of plants, the average height of those remaining alive at the beginning of their third growing season was actually less than it was at the close of their seedling year. In the fall of 1955, a 1-acre game exclosure was constructed by the Idaho Fish and Game Department for the dual purpose of research and demonstration. A 5-acre area, which includes this plot, was seeded to bitterbrush by what past study and experience indicated was the best method. Plans for the next several years include close observation of the effect of game on this plantation.

Bitterbrush nursery stock.--Two small-scale studies to determine a sound method of field planting of nursery-grown bitterbrush stock were begun last year. Results to date indicate the need for control of competing vegetation close to the seedling, and show 1-0 stock to be superior to 1-1 stock in ability to survive after being planted in the field.

Rodent control.--Rodents, mainly mice, have been a problem in bitterbrush field seedlings because of their seed-gathering habits. In places they have disturbed nearly 100 percent of the seed spots within a few days of planting. With the cooperation of the Denver Wildlife Research Laboratory of the U. S. Fish and Wildlife Service, a comparison of seed treatments with three chemical substances that may either poison rodents or repel them from the seed after it is planted was carried on in the fall of 1955. Observations a few days after seeding showed one substance to have little, if any, more value than no treatment at all. The other two showed considerable promise, but observations early in the spring of 1956 will be necessary to evaluate the efficacy of the treatments.

Big-Game Range Revegetation in Utah

In the spring of 1955 a game-forage project was organized in Utah to discover plants and suitable procedures for revegetating depleted deer ranges. This is a cooperative undertaking of the Utah State Fish and Game Department, U. S. Fish and Wildlife Service, and Intermountain Forest and Range Experiment Station. Headquarters for the work is at the Great Basin Research Center.

Trials with Nursery Stock

Transplants were put out on three sites in central Utah where the soil has been derived largely from limestone or shale. Annual precipitation averages 14 to 15 inches.

Site 1 is an abandoned dry-farm in the upper sagebrush zone having a good soil with above-average moisture-holding qualities. The vegetal covering before planting was one of annuals--cheatgrass, winter rye, and Russian-thistle. Deer concentration is heavy in late winter and early spring.

Site 2, within the lower mountain-brush zone has a deep, rich soil. It is within an area where there is considerable deer concentration. The competing cover of perennial grasses was eliminated by fall plowing. Slopes on sites 1 and 2 are less than 10 percent, so machinery could be used in planting.

Site 3 is a harsh south exposure within a natural opening of Utah juniper. It has a thin soil with many interspersed boulders, preventing use of machinery in planting. Junipers on the edge of the opening were killed by singeing with a flame thrower to eliminate the drain of the moisture by juniper roots. Virtually no competing herbaceous cover exists. Deer use is heavy on such south exposures from fall until spring.

On sites 1 and 2, 8-inch furrows, approximately 3 feet apart, were made with a moldboard plow and jeep. Plants were placed in furrows, after which soil was pushed back on the roots. The jeep was then driven over the covered furrow so soil was packed around the roots. Site 3 was much too rocky and steep to make furrows, so plants were placed in holes 8 inches deep, made with a Pulaski. Thirty species of browse were used on site 1 and 36 species on sites 2 and 3.

In general all species showed best survival on the good soil of mountain-brush site 2 (table 12). Survival was nearly as good on the rocky soil of pinyon-juniper site 3, but growth was markedly less there. Both survival and growth were least on the good soil of sagebrush site 1. A big factor here was competition from annual weeds: western sand cherry, for example, had only 25 percent survival when not weeded, 50 percent survival when weeded once with a duckfoot cultivator, and 100 percent survival when weeded twice.

Table 12.--First-year survival of some of the most promising brush species on three sites: (1) abandoned dry farm in sagebrush zone, (2) mountain-brush zone, and (3) juniper-pinyon type.

	Site 1	Site 2	Site 3
Buckthorn, Dahurian (2 yr.)	2	50	93
Rhamnus davurica (3 yr.)	12	100	100
Cherry, Chinese bush *Prunus japonica*	3	90	100
Cherry, western sand *Prunus besseyi*	58	100	100
Honeysuckle, tatarian *Lonicera tatarica*	57	100	100
Lilac, common (Nebraska)	43	100	93
Syringa vulgaris (Utah)	3	95	93
Mulberry, Russian *Morus alba tatarica*	22	100	93
Olive, Russian (Nebraska)	47	100	90
Eleagnus angustifolia (Utah)	58	100	93
Rabbitbrush, rubber[1] *Chrysothamnus nauseosus*	48	95	93
Sagebrush, big[2] *Artemisia tridentata*	95	100	93

[1] Stem cuttings
[2] Wildings

Survival of Russian olive from Utah and Nebraska was quite similar. However, the Nebraska stock produced considerably more growth than the Utah stock and was the more vigorous at the close of this first growing season. This indicates a difference in nursery stock which is of considerable importance. Another point of interest was the better survival of 3-year than of 2-year nursery stock of Dahurian buckthorn. The larger nursery stock is also easier to handle.

Seedling transplants

Fourteen 1-inch seedlings, about 6 weeks old, were planted in a Latin-square arrangement on the mountain-brush site in 4-inch furrows, with plants 2 feet apart each way. First-season survival percentages were as follows:

Big sagebrush, *Artemisia tridentata*	100	Salt tree, *Halimodendron halodendron*	86
Fourwing saltbush, *Atriplex canescens*	93	Cliffrose-bitterbrush natural hybrid	71
Bitterbrush, *Purshia tridentata*		Cliffrose, *Cowania stansburiana*	36
local strain	86		
Boise strain	29	Mountain-mahogany, *Cerococarpus montanus*	0

The strain difference in bitterbrush is noteworthy.

Salt tree is a leguminous shrub introduced from Russia in 1924 which has grown well in the northern Great Plains. Its value as a browse plant is unknown: rodents showed a high preference for its foliage.

Seedlings of the cliffrose-bitterbrush hybrid, seed of which was collected by W. L. Robinette of the U. S. Fish and Wildlife Service in the Oak Creek Mountains in 1954, have the vigor of the best bitterbrush seedlings and are superior in this respect to cliffrose seedlings. Leaves with three lobes at the apex, as in bitterbrush, or four to seven lobes, as in cliffrose, may be found on the same bush. As in cliffrose, the leaves tend to be persistent through winter. The achenes have a vestigial plume, but otherwise they resemble achenes of bitterbrush more than cliffrose.

Seedling transplants of four species were also set out on a harsh south exposure, with the following first-season survival:

Fourwing saltbush	76
Big sagebrush	44
Bitterbrush (Boise strain)	0
Blue flax, *Linum lewisii*	62

Blue flax is a forb with remarkable ability to grow on south exposures as an associate of shrubs. It produces early green herbage which deer have been observed to relish. Palatability becomes low in late spring when flower stalks are produced and the foliage becomes fibrous, but it does have value as a deer forage in early spring on harsh south exposures where deer concentrate.

RODENT-RANGE RELATIONS

Studies of the effects of pocket gophers on seeded range are being conducted on Monte Cristo, Cache National Forest. This open herbaceous range, in an aspen parkland at about 8,500 feet elevation, has been severely depleted by overgrazing for many years. Until it was artificially seeded, this open type was dominated by tarweed (*Madia glomerata*), and loss of topsoil has been widespread. Table 13 shows grass production on two 3-acre seeded areas--one with close gopher control, the other with a heavy population of pocket gophers.

Table 13.--Grass production by soil type with gophers controlled and present, 1953-1955

	1953	1954	1955
	Pounds per acre, green weight		
Gophers controlled			
Gray soil	2,232	817	1,870
Brown soil	1,780	470	1,570
Gophers present			
Gray soil	1,445	420	1,000
Brown soil	585	120	150

The two areas are believed to be about equal in potential productivity and both have gray and brown phases of the same soil type. The brown soil is much more heavily infested with gophers than the gray. Gophers are primarily responsible for the differences in production shown. They affect grass plants in the following ways:

1. Their winter casts melt out in spring and partially seal the soil against water infiltration. This, together with numerous tunnels, contributes to drought and is especially detrimental to seedlings.

2. Plants are undermined and sometimes pulled into the gopher runways.

3. Plants are killed by gopher digging and by being covered with dirt mounds.

4. Plants are clipped just beneath the root crowns--presumably underneath a snow cover.

Soil moisture samples and permeameter readings indicate greater water penetration on the gopher-free than on the gopher-infested area.

SPROUTING OF BITTERBRUSH FOLLOWING TOP REMOVAL

Much bitterbrush, one of the most important browse species on western ranges, has been burned in recent years, chiefly as a result of widespread use of fire for sagebrush eradication. Although but little sprouting of bitterbrush has been observed in the western Great Basin and California, sprouting from the root crown following burning is common in eastern Idaho. Because of the importance of sprouting in the maintenance of satisfactory stands of bitterbrush, a study was made on the Upper Snake River Plains of the relative effects of fire and complete top removal on this shrub.

Sprouts on both burned and severed bitterbrush plants originated in two different ways: from an existing mass of dormant buds wholly or partly encircling the stem at ground level or from a callus of meristematic tissue formed beneath the bark after treatment and encircling the stem. An examination of a large burn indicated that dormant bud masses were present on 70 percent of the bitterbrush, but many of these had been killed by fire. Nearly twice as many plants sprouted from the callus formed beneath the bark as from existing buds.

Fifty percent of the experimentally burned plants produced sprouts, whereas nearly 72 percent of the bushes sprouted following top removal by clipping. Date of treatment had little effect on number of plants that sprouted following clipping, but burning in May and June resulted in more sprouting than in other months. Burn intensity strongly affects sprouting; date of burning--and corresponding soil moisture--appears important only as it causes differences in intensity. There was a fairly high mortality of plants that sprouted following both burning and top removal, and losses were greater among sprouts from burned than from severed plants.

At every date, more bushes sprouted following experimental burning or clipping on a former burn than on a previously unburned area. This indicates a selective action of fire and suggests that sprouting of bitterbrush is influenced by genetic as well as environmental factors.

BIG GAME-LIVESTOCK RANGE

Grazing Pressures and Plant Composition

Excessive grazing pressures by different kinds of animals have produced striking ecological changes. Table 14 illustrates such changes in the mountain-mahogany type grazed mostly in winter by deer and in spring and fall by livestock.

Table 14.--Plant growth and range condition in relation to grazing use on curlleaf mountain-mahogany type

Forage	Good condition range	Range heavily overgrazed by: Deer only	Cattle only	Sheep only	Cattle & deer
	Plant growth-lbs. per acre air-dry				
Curlleaf mountain-mahogany	815	15	1,315	750	55
Sagebrush	125	135	240	465	290
Other shrubs (low quality)	--	--	50	20	200
Perennial forbs	230	190	18	7	20
Perennial grasses	925	1,010	7	7	35
Annuals	Trace	Trace	40	65	100
	2,095	1,350	1,670	1,314	700
Percent bare soil	9	13	26	23	34

For these curlleaf mountain-mahogany ranges it is evident that:

1. Range in good condition has a mixture of browse, forbs, and grasses well suited to grazing by both deer and livestock and supplying adequate soil protection.

2. Overgrazing by deer alone destroys choice browse species. (In extreme cases sagebrush also is destroyed.) Ground cover remains good on the better soils because grasses fill in where shrubs die (but on dry, steep slopes of loose soil, material soil disturbance may result).

3. Heavy overuse by cattle or sheep alone destroys the perennial grasses and forbs and permits shrubs such as sagebrush and curlleaf mountain-mahogany to increase. Soil is exposed to erosion.

4. Overgrazing by both deer and livestock destroys palatable grasses, forbs, and browse, and permits the increase of low-value shrubs and annuals. Soil is exposed to erosion.

Big Game-Livestock Competition

Deer-cattle studies on Oak Creek range in Utah revealed that one-fifth of the summer range and one-third of the winter range were grazed heavily by both deer and cattle. Management of this deer-cattle range should be based on proper utilization of forage on these key areas where competition for forage is most severe. In summer deer fed mainly on forbs and browse, while cattle relied mainly on grass if available. Most choice deer foods were used somewhat by cattle but deer used little grass except for a short period in early spring. Browse was the main deer food in winter and most of their choice browse species were used by cattle spring and fall. On all deer-cattle ranges studied maximum sustained grazing use is limited by (a) proper use of perennial grasses for exclusive cattle grazing, (b) proper use of palatable shrubs and forbs for exclusive deer grazing, and (c) proper use of shrubs and forbs palatable to both kinds of animals for maximum combined deer-cattle grazing.

Sheep compete more with deer for forage than do cattle, both in areas grazed and in choice of forage. On Monroe Mountain in Utah sheep and deer both grazed about 80 percent of the area intensively. The greatest utilization by deer occurred on the areas used in common. Forbs and browse were prominent in the summer diet of both deer and sheep. Most of the choice deer forage species were also good sheep forage. On summer range 6 of the 10 species most prominent in each diet were also prominent in the diets of both. The chief difference was in a much greater utilization of grass by sheep. Spring diets of sheep and deer on a depleted foothill range were very similar and consisted chiefly of young grasses and browse. Browse species grazed by sheep in late fall were the same as those preferred by deer in winter.

CATTLE GAINS AT BENMORE

The cooperative study at Benmore with the Animal Husbandry Department of the Utah State Agricultural College, involving 12 spring grazing treatments on twenty-four 100-acre pastures of crested wheatgrass, was continued through the eighth consecutive year in 1955.

Whereas at the outset heavily grazed pastures produced the highest cattle gains per acre, 1955 was the second consecutive year in which gain per acre for animals over 6 months of age was less on heavily grazed than on lightly grazed pastures. (Per-acre gains on moderately grazed pastures have exceeded those on heavily grazed pastures for several years.) In 1955, average gains per acre on lightly, moderately, and heavily grazed pastures were 27.8, 29.1, and 22.5 pounds, respectively. When the calf gains are added, total gains per acre become 36.0, 38.0, and 33.9 pounds for the respective treatments.

Average daily gains continued high in 1955 (table 15). It is readily seen that cows with calves are affected more by heavy grazing than either dry cows or yearlings. As with older animals, calf gains are lower under heavy grazing than for the light and moderate intensities of use.

Table 15.--Average daily gains per head of different classes of cattle under light, moderate, and heavy grazing from 1952 to 1955, inclusive

Class of cattle	Light	Moderate	Heavy
Calves	1.86	1.84	1.72
Yearlings	2.68	2.51	2.30
Cows with calves	3.09	2.82	1.89
Dry cows	3.46	3.39	2.76

CONTROL OF UNDESIRABLE PLANTS

Sagebrush Control by Burning vs. Rotobeating, Railing, and Spraying

A study was started on the Upper Snake River Experimental Range in 1952 to compare the effects of sagebrush burning with three other accepted methods of sagebrush control that also maintain the native herbaceous understory. Five adjacent areas, approximately 12 acres each, were selected in a dense stand of big sagebrush with a good understory of perennial grasses and forbs, and were treated as follows: burned, rotobeaten, railed, and sprayed with 2,4-D. One was left as an untreated check.

Data on herbage production available to livestock in air-dry pounds per acre were collected prior to treatment, 1 year after, and 3 years after treatment.

All methods resulted in substantial reduction in big sagebrush, both in production and numbers of plants (tables 16 and 17). Unfortunately, results from the sprayed area do not typify the intensity of sagebrush kill that can often be obtained by using 2,4-D. The poor kill with it in this instance was attributed to poor distribution of spray rather than inherent limitations of the method. Railing was the least satisfactory method in killing sagebrush. Living sagebrush plants on the burned area are all from seed germinating after the burn and are relatively small, whereas some of the plants on the other areas are older plants surviving the treatment.

Table 16.--Numbers of sagebrush plants per 48-square-foot plot before and after treatment

	1952 Prior to treatment	1953 First year after treatment	1955 Third year after treatment
Untreated	11.6	10.4	11.9
Burned	9.8	1.5	2.8
Rotobeaten	10.7	2.0	3.6
Railed	10.7	3.8	6.2
Sprayed	11.1	3.5	4.3

Table 17.--Available air-dry production expressed in pounds per acre, and as percentage of production on untreated check area

	1952 Prior to treatment		1953 1st year after treatment		1955 3d year after treatment	
	Pounds	Percent	Pounds	Percent	Pounds	Percent
UNTREATED						
Grass	133		126		202	
Forbs	35		53		71	
Sagebrush	200		247		296	
BURNED						
Grass	134	101	160	127	292	144
Forbs	49	140	267	504	268	377
Sagebrush	183	92	1/ T	0	42	14
ROTOBEATEN						
Grass	149	112	199	158	483	239
Forbs	26	74	109	206	137	193
Sagebrush	202	101	28	11	45	15
RAILED						
Grass	125	94	154	122	282	140
Forbs	57	163	170	321	177	249
Sagebrush	157	78	57	23	106	36
SPRAYED						
Grass	163	122	213	169	361	179
Forbs	46	131	54	102	78	110
Sagebrush	165	82	99	40	115	39

1/ T = seedlings

Grass, which increased on the untreated area over the 3-year period, increased much more on the areas where sagebrush had been controlled (table 17). Although the increase in available grass on the railed area was about the same as that on the burned area, and the increase on the sprayed area was somewhat greater, considerable grass also occurred on the railed and sprayed areas that was not considered available because of standing shrubs. Rotobeating, on the other hand, resulted in the most available grass primarily because there was no initial reduction in vigor as in burning, and the impeding shrubs were knocked down to make all the grass accessible. Apparently production of grass is continuing to increase under all treatments as vigor is improved and newly established individuals come into production.

Burning favored available perennial forb production markedly more than any other control method, and spraying less. An increase in available forbs also occurred with rotobeating and railing. In contrast to the reaction of grasses, forbs responded most markedly the first year after treatment, and since then their production has tended to level off.

It is interesting to note nature's compensating play when a catastrophe occurs to a particular component of vegetation. Upon an immediate reduction of shrubs, herbaceous species vie for the released moisture, nutrients, and light. Apparently certain forbs are best able to take initial advantage of this available resource by rapidly increased growth. This is illustrated by the great increase in forb production the first year after treatment. Grasses appear to be a bit slower in exerting competitive pressures, but are able to increase longer at the expense of the forbs, as illustrated by the continued increase of grass production and leveling off of forb production. These generalizations need to be qualified, of course, by the recognition that some species of forbs or grass respond differently than others to burning, spraying, railing, and rotobeating.

Burning is by far the least expensive of the four methods used to control sagebrush. Costs of the different methods may vary considerably, but the following figures are indicative of comparative costs per acre: burning, \$0.70; rotobeating, \$3.00 to \$5.00; railing (twice over), \$2.00 to \$2.50; spraying with 2 pounds 2,4-D, \$2.50 to \$3.00.

Changes Following Goatweed Control

Composition transects established at Milan in northeastern Washington to follow vegetal changes brought about by control of goatweed (*Hypericum perforatum*) with the beetle *Chrysolina gemellata*, indicate not only degree of control but also the plant species filling the void created by reduction of goatweed. Although beetles were planted in 1951, their effect was not apparent until after the transects were established in 1953.

Between 1953 and 1955 goatweed in the vicinity of the planting was reduced from an initial 23.5 percent composition to 0.9 percent (table 18). On this site cheatgrass (Bromus tectorum) and Italian bentgrass (Agrostis interrupta), both annuals, replaced goatweed in the stand. During the same 2-year period amount of litter on the ground decreased and exposure of bare soil increased.

Table 18.--Composition changes on goatweed-dominated range determined 3/4-inch loop method (650 loops distributed on 8 transects)

Item	Percent composition 1953	 1955
Bare soil	14.8	22.5
Erosion pavement	1.0	0.8
Rock	4.3	2.8
Litter	43.4	30.5
Moss	--	2.5
Agrostis interrupta	5.4	13.8
Apocynum pumilum	0.1	0.2
Bromus tectorum	2.9	18.5
Hypericum perforatum	23.5	0.9
Lappula sp.	2.6	--
Lepidium sp.	--	4.8
Lotus purshianus	0.5	1.8
Poa secunda	0.2	0.1
Others	1.3	0.8

Range Weeds in Montana

Initial phases of the range research problem analysis in Montana have revealed the spread of noxious weeds on both range and forest lands as a major problem. As would be expected, invasion by these weeds has been most rapid on areas where the native vegetation has been severely disturbed, as on overgrazed ranges and cutover timber lands. However, there are indications that some of the noxious species are also invading grasslands in fairly good condition.

Some of the most abundant weeds are goatweed (Hypericum perforatum), Canada thistle (Cirsium arvense), Russian knapweed (Centaurea picris), wyethia (Wyethia amplexicaulis and W. helianthoides), and leafy spurge (Euphorbia esula).

Sagebrush (Artemisia tridentata) and cheatgrass (Bromus tectorum) might also be considered in the category of troublesome weeds, although, in contrast with the foregoing species, considerable information is available on their ecology and methods of control. Goatweed is very abundant on the west side of the Continental Divide in Montana, but is of little consequence on the east side. Canada thistle is widespread in the lowlands; its occurence on national forests is confined to relatively small patches. Russian knapweed is very abundant in some areas, particularly in the Bitterroot Valley and on adjacent areas of the Bitterroot and Lolo National Forests. Wyethia is abundant on limited portions of the Gallatin and Beaverhead Forests, but elsewhere is of minor importance. Leafy spurge is confined mostly to cultivated lands but has invaded some range and forest lands, particularly on cutover areas.

Control of noxious weeds on wild lands is important because these plants are replacing desirable forage species and in some cases may be preventing proper reproduction of forest trees. Weed infestations on range and forest areas are also a source of contamination for cultivated lands, which is a cause of considerable concern to weed control districts. This situation in Montana and elsewhere has led to the introduction of, a number of bills in Congress pertaining to noxious weed control on public lands.

Although certain direct control methods have been effective on cultivated areas, they are often too expensive for use on wild lands. If indirect control through management is to be achieved, it will be necessary to obtain information on the ecology of these weeds, particularly about the conditions under which they invade new areas. Ecological information is also needed to provide proper management for preventing reinvasion of weeds following eradication. In the case of cutover areas, it may be worthwhile to investigate the possibilities of seeding with herbaceous species to prevent invasion of noxious weeds until timber reproduction again gains control.

Halogeton on the Desert Winter Range

In the fall of 1952 halogeton (H. glomeratus) was found on a small area adjacent to the playa on the Desert Experimental Range. The plants were small and few, scattered over approximately 8 acres along the edge of the salt flats where Kochia vestita, Atriplex confertifolia, Sarcobatus vermiculatus, and Salsola kali tenuifolia occur sparsely. Halogeton plants were established on bare, saline soil but seemed to prefer soil mounds around established plants. No other halogeton infestations were found adjacent to the Desert Experimental Range in 1952, but in 1953 a heavy infestation was located approximately 4 miles southeast along the drainage into the experimental area. Probably this was the seed source for the plants found the previous year.

By 1953 the small infestation within the experimental area had spread 2 to 3 miles across the playa and seedlings were found in the vegetation along its borders. Infested spots were also found in Antelope Valley 10 miles to the west, in Snake Valley 1 mile to the north, and in Pine Valley along the eastern boundary and southeastward from the Experimental Range.

In June of 1954, four small areas in white sage and shadscale types were seeded to halogeton. On each area two plots approximately 8x8 feet were planted. One plot was cleared of vegetation. On the other the seed was raked in among the native plants. All plots produced halogeton plants in 1954. Because of drought the plants were small, averaging only 5 to 6 inches in height, and the number per plot varied from 8 to 23. The plants apparently produced seed on most of the plots and in 1955, another drought summer, plants were found on three of the areas.

On area No. 1 in a good white sage stand, halogeton had spread approximately 130 feet, and the plants varied from 1 to 5 inches in height. On area No. 2 in mixed shadscale-white sage, no halogeton plants were found: either the plants did not mature seed, the seed did not germinate, or seedlings failed to become established. On area No. 3 on heavily grazed range, halogeton spread approximately 40 feet and plants averaged 3 to 8 inches. On area No. 4 on moderately grazed range in the shadscale-winterfat type, halogeton spread only about 8 feet and the plants were 8 to 10 inches tall with 15 to 20 plants in the original cleared plot. These preliminary observations suggest that halogeton cannot be excluded from desert-shrub range, but perhaps it can be suppressed by the perennial vegetation, and its effects on livestock minimized, if the range is in good condition.

Halogeton is now well distributed around the Experimental Range. It occurs on the road at several places along the eastern boundary; it also occurs along the western boundary in Antelope Valley. By the end of 1956 it will probably surround the Experimental Range on all sides.

ASPEN SITE POTENTIAL

The aspen type includes many openings which often have a herbaceous or herb-shrub cover very different from the understory of the aspen itself. As a rule, vegetation of openings is sparser and shorter, and tends to include a smaller proportion of desirable forage species, than vegetation beneath the aspen canopy. In trying to visualize productive potentialities of the type, the question arises as to whether this difference is natural, or whether, like so many changes in range vegetation, it has been brought about by heavier grazing in the openings. Observations have shown that there is a tendency, marked with cattle and somewhat less marked with sheep, for utilization of forage to be heavier in openings than under extensive stands of aspen. (At the edges of some stands, and in small patches of aspen where animals shade up, the reverse is often true.)

A practical application from knowledge of potential productivity is found in judging range condition. If the potential in openings is less than that under the aspen canopy, then the openings and understory vegetation cannot be judged by the same criteria. If the productive potential in the two habitats is the same, not only can their condition be judged by the same criteria, but perhaps differences between them may be significant as indicators of range condition. Finally, if the productive potential of open-growing vegetation is greater than that of understory vegetation, criteria needed for the openings should be the more exacting.

A clue to the answer is provided by the fact that, in those few stands which have escaped heavy grazing for many years and which are therefore presumed to be nearer to pristine than most range, differences in production under the canopy and in the open are much less than the differences on the prevailingly heavily grazed range. In fact, there is a suggestion that production in the openings may actually be greater than production under the trees, an opposite difference to that encountered on heavily grazed range. The trouble with this evidence is that such ungrazed areas are few and small and are mostly in rough, rocky terrain that is not entirely typical of the broad aspen type which is usually found on gentle slopes and flats with rather deep soil.

In order to measure potential productivity, plots were seeded at four locations in Ephraim Canyon in central Utah in 1950. One set of plots at each location was put in the open near an aspen stand, and two sets of plots were established within the stand, one of which was trenched each year of the study to a depth of 2 feet to cut the aspen roots. The trenches were refilled. Subplots were seeded to *Bromus carinatus*, *Elymus glaucus*, *Heracleum lanatum*, and *Rudbeckia occidentalis*. Considerable difficulty was experienced in getting full stands of some species, and since *Bromus* was most uniformly successful, it will be used as an example to summarize the salient results.

Table 19 shows that production on the open plots exceeded that of the untrenched plots under the aspen. This relation is consistent for *Bromus*, and, if poor stands are excluded, for *Elymus* and *Rudbeckia*. No fully stocked open stands were obtained with *Heracleum*. These results indicate that the productive potential of the openings is fully as great as that under the aspen, and probably is greater.

Table 19.--Air-dry production of Bromus carinatus, in grams per 9.6 sq. ft., 1953

Elevation of site	Open	Under aspen	
		Untrenched	Trenched
Feet			
9,000	128	30	171
8,800	116	58	133
8,450	47	17	97
8,050	51	36	89

Turning now to the figures for trenched and untrenched plots under the aspen, it is seen that production on the trenched plots is consistently higher than on the untrenched plots. This is true for the other three species also. It is clear, then, that aspen does suppress understory vegetation.

It is concluded that the productive potential may be greater in openings than under the aspen canopy despite the advantages provided by the overstory in shade, lower evaporation, soil fertilization through leaf fall, etc. This study confirms the evidence from natural areas showing that potential production of herbaceous vegetation in aspen openings is at least as great as, and probably greater than, potential production within the aspen stand. Probably the benefits conferred on the understory by the aspen are outweighed by the demands of aspen for soil water.

This study provides a basis for defining condition in the aspen type more accurately than has heretofore been possible. For extensive areas of aspen range to be in satisfactory condition, the production of herbage in openings should be at least as great as production under the aspen canopy, and perhaps one may say that for excellent condition productivity should be materially greater. Probably--from observation of natural areas--species composition should not be greatly different in openings and under the aspen overstory.

RANGE RESEARCH METHODS

Interpretation of Vegetal Changes from Loop Hits

One of the primary objectives in the development of the 3-step method was the simple and accurate measurement of vegetal changes. The data obtained from the precise part of the method, the loop readings, are intended to serve as benchmarks for future readings. Presumably the changes recorded in the loop readings for a specific item over a period of time, coupled with other extensive wide-scale estimates, are indicative of trends. The reliance which the observer can place on his conclusions regarding trends depends largely on the magnitude of differences recorded by the loop and on his knowledge of the vegetal type under consideration.

A study was made at the Upper Snake River Experimental Range to test the correlation between changes in loop hits and changes in root crown areas. The most abundant species on the site chosen for the study were Agropyron spicatum and Balsamorhiza sagittata and the site was classified in good condition.

Table 20 shows total number of plants, total area occupied by root crowns, and average size of root crown area for each species. It is of interest to note that the root crowns of Balsamorhiza occupied more area than those of Agropyron, although the Agropyron plants were about 10 times more numerous. Comandra is also of interest because it was represented by almost as many plants as Balsamorhiza and yet its total root crown area was insignificant by comparison.

Table 20.--Amounts of the three measured species on 8 belt transects on the study area

	Agropyron spicatum	Balsamorhiza sagittata	Comandra umbellata
Total plants	2,250	268	249
Total root crown area (cm.^{2})	4,679	6,289	24
Av. root crown area (cm.^{2})	2.08	23.4	0.09

In this study, the total root crown area of Agropyron spicatum, Balsamorhiza sagittata, and Comandra umbellata was determined by measuring the cross-sectional area of every plant on each of 8 belt transects 9 inches wide and 100 feet long, and loop readings were taken at 6-inch intervals, i.e., 200 readings per transect. Random removals of measured root crown areas followed by loop readings were then made three times on each transect. This procedure resulted in two independent indices of change of 100 loops each (100 loop readings at half-foot marks and 100 at foot marks) and one index of change of 200 loops or a total of three indices for each change on every transect. Since there were three removals (changes) made on each transect the total number of indices obtained for a transect was 9; six 100-loop and three 200-loop indices.

When the root crown areas and their associated loop-hit values were plotted and the regression of root crown area on loop hits computed it was evident that loop hits did not give a satisfactory index to the amount of surface occupied by root crowns. For example, 8 loop hits indicated 173 sq. cm. of Agropyron on one plot, 342 sq. cm. on another, and 638 sq. cm. on still another. These differences were observed on transects where the sampling consisted of 200 loop readings per transect. Where 100 loop readings were taken, the differences were greater in most cases.

The inability of the loop technique to furnish a satisfactory estimate of root crown area is incidental to the primary objective of this investigation which was to test the ability of the loop to detect change in root crown area.

When the average root crown areas of the 8 transects, as determined by actual measurement, are compared with the average loop readings, the changes in root crown areas are rather accurately reflected by the changes in loop hits. Table 21 illustrates this relation based on averages of 8 transects for Agropyron. Out of the 9 indices of change provided by the loop hits as shown above, one differs from the actual by 11 percent (88% - 77% = 11%); the other 8 are within 9 percent or less of the actual change. The data for Balsamorhiza showed a correlation between changes in loop hits and changes in root crown areas that was equally good. There was little gained with either species by increasing the number of loop readings from 100 to 200 per transect.

Table 21.--Loop hits on 8 transects at 100 or 200 loops per transect as known amounts of Agropyron were removed

Removal	Av. root crown area		100 loops[1]		100 loops[2]		200 loops	
	Cm^2	Percent	Loop hits	Percent	Loop hits	Percent	Loop hits	Percent
0	585	100	5.4	100	6.5	100	11.9	100
1	514	88	4.4	81	5.0	77	9.4	79
2	374	64	3.6	67	4.5	69	8.1	68
3	263	45	2.4	44	3.5	54	5.9	50

[1] Loop hits at foot marks
[2] Loop hits at half-foot marks

It is obvious from this tabulation that 8 transects of 100 loops each provided a good index to the changes that actually occurred on the site studied. However, in the practical application of the loop technique the observer is likely to have fewer than 8 transects on which to base his estimates. In order to determine the minimum number of transects required to furnish a good index to change, under the conditions of this study, the following procedure was adopted. Three groups of 7 transects each were chosen at random from the total of 8 transects. The average root crown areas and loop hits of each group were determined and compared. This same technique was used with groups of 6, 4, 3, and 2 transects each. The results of these group comparisons are shown in table 22.

Table 22.--Percent of 100-loop and 200-loop indices of change in root crown area of Agropyron and Balsamorhiza that differed from the actual change by 10 percent or less; data obtained from averages of groups of 2, 3, 4, 6, and 7 transects each

Number of transects per group	Agropyron		Balsamorhiza	
	100 loops	200 loops	100 loops	200 loops
	Percent		Percent	
7	78	89	95	100
6	67	100	50	100
4	56	78	50	67
3	44	56	61	67
2	39	44	28	33

It is of interest to note that when the number of transects dropped to 6, only two-thirds of the indices obtained from the 100 loop readings for Agropyron and only half for Balsamorhiza were within 10 percent of the actual changes. Table 22 also shows that in every instance the percentage of indices falling within the allowable 10-percent error was greater when the number of loops read per transect was increased from 100 to 200. With 7 transects there is some doubt as to whether the increase in accuracy afforded by the 200 loop readings is sufficient to justify the concomitant increase in time and effort. Where 6 transects were used there is no such doubt.

The 10-percent standard of accuracy chosen for this study is, of course, arbitrary. If the observer is willing to accept larger differences he can obviously get a larger percentage of his indices within his acceptable error without increasing the number of transects in the sample. On the other hand, if only smaller differences are considered significant, the volume of sampling must be increased in order to maintain a selected percentage of loop indices within the acceptable limits. If the 10-percent error is acceptable, it is apparent from table 22 that in order to obtain a satisfactory loop index of change in these two dominant species a minimum of 7 transects of 100 loops each is required. If the loop readings are increased to 200 per transect, 6 transects will suffice.

Although Comandra umbellata, the third species tested, occurred on every transect, only one loop hit was recorded on it during the entire test. It is therefore clear that, to detect changes in minor species in the stand, much more intensive sampling is needed than even 8 transects of 200 loops each.

Errors in reading the loops occurred 8 times, i.e., a hit recorded at one reading was missed in a subsequent reading or vice versa, even though no change had been made and the steel tape was left in place between readings.

WATERSHED MANAGEMENT RESEARCH

This division is concerned with finding solutions to three kinds of watershed management problems on the forest and range lands of the Station territory. Part of the study program is aimed at determining how to restore control of runoff and mantle stability on lands where plant cover has been depleted and erosion of slopes and channels has been accelerated by improper land use. Other studies are being made to determine how to maintain satisfactory watershed conditions while providing for use of the timber, forage, and other land resources. A third group of studies is directed toward finding ways of managing the vegetation and soil so as to increase the amount or improve the timeliness and quality of water yields.

Progress was made on all three of these major problems during the past year through continuation of experimental studies at the Great Basin Research Center in central Utah, the Wasatch Research Center in northern Utah, and the Boise Research Center in southwestern Idaho. In addition, an analysis of the watershed problems in the Montana, northern Idaho, and eastern Washington portions of the Station territory was undertaken at the Missoula Research Center. This analysis, though not yet complete, shows there are many watershed problems in both the upper Columbia and upper Missouri River basins on which research is needed. These needs are to be given further consideration in the coming year as a basis for developing a watershed management research program and assignment of study priorities.

WATERSHED RESTORATION

Floods continued to plague the region in 1955. Some came in the summer following localized, short duration but high intensity rains. Others came in mid-December following prolonged rains that melted much of the snow which had begun to accumulate on the mountain slopes. Virtually all of the summer rain floods and much of the runoff in the rain and snowmelt floods came from damaged watershed lands.

The summer floods followed a familiar pattern. The Cedar City area in southern Utah, and the Mt. Pleasant area in central Utah were again damaged, as they have been many times in recent years. The source of the newest floods, like those of the past, were high elevation depleted range lands that have lost their capacity to absorb and store water. However, summer floods were not confined to Utah. Similar flash floods from similarly damaged summer range lands also occurred on tributaries of the Salmon and the Boise Rivers in central Idaho.

The most publicized of the winter floods occurred in the Reno, Nevada area from the Truckee river watershed on which there has been widespread depletion of the plant cover by repeated timber cutting, fires, and overgrazing. There, in a 5-day period in December, from 10 to 20 inches of warm rain melted much of the snow that had accumulated. A discharge of 18,000 c.f.s.--6,000 c.f.s. above channel capacity--caused damage in the Reno area of about $5,000,000. Much greater damages were averted only because an inflow of cold air changed the precipitation during the following 3 days from rain to snow.

Similar, prolonged rain on snow also produced major floods on the Little Salmon, Payette, and Boise Rivers in Idaho. Discharges on the Payette River rose from 5,000 c.f.s. to 26,000 c.f.s. in 18 hours, a new record for that stream. The full extent of damages in the Idaho areas has not yet been determined. However, it is known that great quantities of sediment were carried into downstream reservoirs from ripped channels, washed out highways, poorly covered burned-over lands, and deeply gullied logging haul roads and skid-trails.

Watershed Restoration, Davis County Experimental Watersheds

The behavior of streamflow in the Parrish and Centerville basins of the Davis County Experimental Watershed during the period 1936 to date is providing much needed information about the effects of upstream watershed restoration measures on perennial water yields derived largely from snowmelt. These areas are also providing information on the control of torrential summer rains.

The Centerville and Parrish watersheds are each about 3 square miles in size. They are adjacent to each other and drain a portion of the western slope of the Wasatch Mountains. Elevations in both extend from about 4,500 to 9,000 feet. The land use and flood history of the two areas is quite different. In the Centerville watershed, the mixed tree, brush, and herbaceous vegetation has never been seriously depleted, though it has been moderately grazed for many years. This area has produced no summer storm mud-rock floods since settlement began in the valley below over 100 years ago. In Parrish watershed, serious plant cover depletion occurred on headwater areas because of overgrazing. Four devastating mud-rock floods occurred from this watershed in 1930. The area was then closed to grazing and the flood-source areas were contour trenched and seeded to perennial grasses in 1934.

It has been determined that mud-rock floods can be generated on depleted lands in the Davis County Experimental Watershed by as little as 0.50 inch of rain, if rainfall rates exceed 1.60 inches per hour for 5 minutes. There have been 20 such storms on the Parrish watershed since 1936. During 8 of these storms, maximum rates exceeded 3.00 inches per hour, and on 2 occasions they exceeded 5.00 inches per hour. Similar rains have occurred in the Centerville watershed. No mud-rock floods have occurred on Parrish Creek since the upstream restoration measures were installed, nor have any occurred on Centerville Creek. By contrast, nearby impaired watersheds not so treated have continued to produce floods under the impact of rains of less intensity than some recorded in the Parrish and Centerville watersheds.

Parrish Creek is now producing high-quality water. Instead of discharging 100-ton boulders and other debris at rates of 9.00 acre feet per square mile of watershed area per year, as it did during and following the 1930 floods, streamflow from Parrish Creek now runs as clear as in Centerville Creek. Water from both streams is diverted directly into both domestic and irrigation water systems.

Restoration of the plant cover on the flood-source areas in Parrish Creek has resulted in a gradual decline in annual water yields amounting to about 1.50 inches over the past 18 years. This decrease has occurred only during the months of March, April, and May when water yields from snowmelt are locally abundant. There has been no discernible change in water yields during the summer and fall months when water is in highest demand. The restored plant cover in many places is now producing 3,000 to 4,000 pounds of good-quality forage where only 500 to 700 pounds of inferior weeds were produced before.

There has been a downward trend in the magnitude of snowmelt peak discharges on Parrish Creek. Though this stream continues to produce greater snowmelt peak discharges than Centerville, the magnitude of the difference between the discharges has been reduced about 50 percent. Maximum daily runoff from Parrish Creek is now tending to occur later in the spring. Whereas it tended to occur 3 or 4 days earlier than Centerville during the years 1936 to 1940, it now tends to be from 3 to 4 days later.

The runoff behavior of Parrish Creek probably has not been fully restored to normal. There is room for further improvement in the plant cover on some of the flood-source areas. More time will also be required for the ripped channels to become refilled. As the condition of this watershed improves, annual runoff may decrease still more. However, there should also be greater control of storm runoff, decreasingly less sediment production, a further lowering and delay of snowmelt peaks, and even greater forage production.

Restoration of Subalpine-Herbaceous Range Watersheds

The artificial reseeding that was done on the depleted Area B watershed at the Great Basin Research Center continues to be effective in providing virtually complete control of summer storm runoff and of sediment production. For the third year in succession, sediment yields were too small to measure and runoff was equally negligible. Meanwhile, plant cover density has increased about 50 percent and the area is now producing about 3 times more forage than it did when last inventoried in 1951. As shown below, there has been a substantial increase in perennial grasses, a decrease in weedy forbs, with little change in litter.

	1951	1955
Plant cover density (percent)	20	33
Live vegetation	14	28
Litter	6	5
Range forage (pounds/acre)	1,100	3,000
Grasses	280	2,600
Forbs	820	400

The new grasses are both well dispersed and in healthy condition. The density of both the grasses and litter is expected to increase in the next year or two. After optimum cover conditions are developed this area is to be used for testing effects of grazing use on its hydrologic characteristics as a means of determining maximum safe amounts of use.

Pleasant Creek Watershed Evaluation Study

During the year the Station provided technical guidance for a study of the hydrologic and productivity effects of an upstream restoration program in the Pleasant Creek watershed in central Utah. This is one of the first areas to be treated under provisions of the Small Watershed Demonstration Project item of the Agricultural Appropriations Act of F. Y. 1954.

As part of this study, infiltrometer tests and records of forage production were made this summer on a variety of flood-source areas prior to their treatment by protection from grazing, plowing and reseeding, and contour trenching. Repeat measurements on the permanently staked plots are scheduled for 1956.

Analysis of the first year's data has not yet been completed. However, the data show very obvious inverse relationships of amount of plant and litter cover to infiltration, storm runoff, and soil erosion. There are variations in these relations also due to differences in the structure and pore space characteristics of the soil.

To supplement the infiltrometer and transect study, runoff plots equipped with sediment catchment basins were established on several paired areas having well developed gullies. One of each pair was not treated, the other was contour trenched and seeded. Sediment production measurements are to begin on these areas in 1956 and will be continued through 1958.

WATERSHED MAINTENANCE

A twofold increase in timber harvesting in recent years and continuing demands for the grazing of livestock and big game have accentuated the problem of maintaining effective control of runoff and soil stability on the watershed lands of the Station territory. During the past year, progress was made on two erosion control studies on the ponderosa pine lands of Idaho, and on a range watershed study in central Utah.

Logging Disturbance-Sediment Production Study

During the years 1953 and 1954, a study of the effects of cutting and logging ponderosa pine on sediment production was undertaken in the Boise Basin Experimental Forest near Idaho City, Idaho. Twenty small watersheds were included in the study, of which 16 were cut and logged, and 4 were left in virgin condition. Debris basins for trapping sediment were installed on all watersheds. In 1955, data were obtained on the area of the forest floor that was disturbed by logging, the amount of sediment trapped in the debris basins, and the amount of sediment that has been temporarily trapped between the eroding source areas and the debris basins.

The areal extent of logging disturbance ranged from 4.0 to 13.5 percent per study compartment. Haul roads were responsible for 45 percent of the disturbed area, skidtrails for 40 percent, and log loading areas 15 percent.

The amount of eroded sediment was too small to be measured on 7 of the logged watersheds but ranged from 1 to 216 tons per square mile on the other logged areas. The greatest sediment production came from watersheds in which haul roads crossed or paralleled a portion of the main drainage bottom.

These first measurements were taken prior to December 1955, when unusually heavy rains on snow caused very serious erosion on extensive areas of ponderosa pine lands in the vicinity of the experimental forest. The advent of heavy snow precluded an examination of the effects of the rainstorm on the experimental areas. These effects will be determined in the coming year following the disappearance of the snow pack.

Postlogging Erosion Control Methods Study

During the past year the first measurements and observations were obtained on 4 erosion control areas on the Boise and Payette national forests. Part of this study is to evaluate the effect of gradient, spacing of cross ditches, and grass seeding on sediment production from temporary logging trail roads. Another part is to test the effectiveness of different types and spacings of erosion control measures on skidtrails. A large mass of data from observations taken immediately after spring snowmelt and after the occurrence of high intensity summer rains is now being analyzed.

This study was expanded during the past year by adding a more comprehensive test of reseeding measures on 2.8 miles of logging road within the Little Owl Creek timber sale area on the Boise National Forest. This phase of the study involves the testing of 9 promising grasses, 4 methods of planting, and site treatment by fertilizer and mulch. The tests are replicated on north and south exposures. The results of this study are expected to lead to more certain and effective erosion control on logging roads than has been experienced to date.

Range Watershed Maintenance Study

With help from the Boise and Wasatch Research Centers, a start was made on a study to determine the safe limits of grazing reseeded subalpine-herbaceous range in the headwaters of Manti Canyon on the Manti-LaSal National Forest in central Utah. The study area is typical of extensive areas of high elevation depleted range. It was plowed and seeded to grass in 1952. Prior to treatment, paired one-half acre plots were located on a variety of slopes, aspects, soils, and plant cover types. One plot in each pair was not treated. The entire area has been protected from livestock grazing since 1952.

As a first step in the study, infiltrometer tests and plant cover observations were made on the treated and untreated plots during the past summer. Analysis of the data has not yet been completed. However, it appears that another year or two may be required for the reseeded sites to attain full plant cover development and maximum control of storm runoff and soil stability. When grazing is resumed in the area, portions of each of the paired plots will be protected from grazing by wire cages. These and the grazed sites will be tested by infiltrometers to determine the effects of grazing on their infiltration, surface runoff, and erosion characteristics. These finds will be correlated with information previously obtained from the Area A and B experimental watersheds as a means of determining safe grazing use.

WATERSHED MANAGEMENT

Wind movement has an important effect on evaporation from the land. Atmometer measurements were made under an aspen forest canopy and on an adjacent grassy opening on the Davis County Experimental Watershed during one growing season. This record showed total air movement for the growing season to be 1,799 miles under the aspen and 8,226 miles, or about 4.5 times more in the open. The greatest difference occurred on September 9 when 74 times as much air movement occurred in the open as under the aspen. During the main part of the growing season, the differences averaged about 6.36 times greater in the open. During the early part of the season, prior to full aspen leaf development, air movement in the open was about 1.50 times greater in the open than under the aspen.

The aspen cover caused an average reduction of wind velocity of 2.6 miles per hour and a relative reduction of 79 percent as compared to velocities in the open. The reduction of actual velocities under the aspen tended to be greater during strong than during light winds.

FOREST WILDLIFE RESEARCH

The Fish and Wildlife Service has cooperated with the Experiment Stations in studying the effects of vertebrates on forest and range since 1940. Particular emphasis has been on the effects of the animals on forest regeneration. The main species studied have been white-footed mice, porcupines, snowshoe hares, and white-tailed deer.

White-footed Mice

Since 1948 studies of mouse populations have been made in conjunction with the Station's seed production and germination studies on the Kootenai Forest. It was found that the mice consume about 90 percent of the seed produced each year in that area. Apparently the availability of seed is a limiting factor in the mouse population, since the number of mice has shown the same trend as seed abundance over the past 8 years. Spring and fall censuses of the mice were conducted as usual this year. A new set of census trap lines were established near the mouth of Wolf Creek to test mouse numbers at plots where the State Fish and Game Department had exclosure plots for browse seed trials.

Porcupines

In 1955 the Fish and Wildlife Service supervised a field survey of porcupine damage to ponderosa pine plantations. The survey was financed by Timber Management of Region 1. The survey indicates that only 24.5 percent of the total plantation area is stocked with planted pine trees. About one-sixth of existing planted pine has been killed or injured beyond hope of reaching maturity. The lost and damaged trees have a replacement value well over $50,000 and most of the trees are only now entering the period of greatest susceptibility to porcupine damage. A report is in preparation to be submitted to the Journal of Forestry.

Snowshoe Hares

A study of the life history, ecology, and population dynamics of the snowshoe hare was started in 1951. A population of hares on a 100-acre island in Flathead Lake has been live-trapped each year since 1953. A detailed report is nearing completion and will be submitted to Ecological Monographs during the coming year.

White-tailed Deer

Deer destroy about $90,000 worth of ponderosa pine each year on a single tributary watershed on the Kootenai National Forest. This has been demonstrated by studies in progress since 1946. Exclosure plots built that year contain seedlings in numbers sufficient to successfully restock their areas. Outside the deer exclosure practically all seedlings are eaten by deer. The suggested remedies are increased hunting pressure to reduce deer numbers, and rotational fencing of 160- to 640-acre tracts. At the 1955 hunting season the State Fish and Game Commission increased the hunting harvest by (1) allowing the killing of either sex deer during the entire hunting season, (2) allowing nonresident hunters to buy Montana licenses for $20 instead of the regular $100, (3) allowing each hunter to kill two deer instead of one, (4) extending the hunting season 2 weeks beyond the regular season. The kill was increased fivefold over those of previous years. It is estimated that about half the desired number of deer were harvested.

PUBLICATIONS

A. Departmental publications

EVENDEN, JAMES C., and KENNETH H. WRIGHT. Douglas-fir beetle. U. S. Dept. Agr. Forest Pest Leaflet 5, 4 pp., illus. July 1955.

Leaflet describing features of Douglas-fir beetle development, method of attack, habits, and control.

PLUMMER, A. PERRY, A. C. HULL, JR., GEORGE STEWART, and JOSEPH H. ROBERTSON. Seeding rangelands in Utah, Nevada, southern Idaho, and western Wyoming. U. S. Dept. Agr. Agr. Handb. 71, 73 pp., illus. January 1955.

Instructions on where, how, and what to seed. Includes indicators of site quality, methods of removing competition, methods and seasons of planting, and descriptions of adapted species suitable for various sites from low-elevation salty lands to open subalpine types.

STRUBLE, GEORGE R., and PHILIP C. JOHNSON. The mountain pine beetle. U. S. Dept. Agr. Forest Pest Leaflet 2, 4 pp., illus. June 1955.

Describes history and distribution of species, stages of development, habits, and control.

B. Publications in scientific and professional journals, etc.

ADAMS, LOWELL. Pine squirrels reduce future crops of ponderosa pine cones. Jour. Forestry 53(1): 35. January 1955.

Pine squirrels cut off twigs in winter to eat the cambium. This destroys vegetative buds with their flower anlagen and attached conelets.

ADAMS, LOWELL. A punch-card bibliographic file for vertebrate ecologists. Jour. Wildlife Mangt. 19(4): 472-476. 1955.

The edge-notch type of punch card is used in designing a system for a bibliography. Advantages of the system are (1) for use of individuals or small groups, (2) multiple cross references are possible with a single card per title, (3) cataloguing system can be minutely detailed and can be modified to fit changing needs.

BINGHAM, R. T., and A. E. SQUILLACE. Self-compatibility and effects of self-fertility in western white pine. Forest Science 1(2): 121-129. June 1955.

Cone and seed yields, germinability, and seedling height following self-pollination of 28 trees were compared against corresponding values for cross-pollination. Considerable tree-to-tree variation in self-compatibility and self-fertility was found. "Self-ability" or yield of self-pollinated seedlings relative to yield of cross-pollinated seedlings also varied considerably, averaging about 50 percent for the 28 trees studied. Seedling height during the first, second, and third years, averaged 11, 21, and 21 percent respectively, below heights of cross-pollinated seedlings.

BOE, KENNETH N. A one-foot-square wire seed trap. Jour. Forestry 53(5): 368-369. May 1955.

Describes construction methods and evaluates efficiency of sampling with the small seed trap.

CRADDOCK, GEO. W. Book review: "The Flood Control Controversy," by Luna B. Leopold and Thomas Maddox, Jr. Jour. Range Mangt. 8(4): 183. July 1955.

ELLISON, LINCOLN. Our weight in the balance of nature. Utah Acad. Sci., Arts & Letters Proc. 32: 11-25. 1955.

Balance developed between vegetation and soil during process of primary succession is described for steep mountain slopes, and importance of controlling accelerated erosion, as an ethical as well as a practical element in sound land use, is emphasized.

EVANKO, ANTHONY B., and ROALD A. PETERSON. Comparison of protected and grazed mountain rangelands in southwestern Montana. Ecology 36(1): 71-82. January 1955.

Authors conclude that leaf height, plant area, and yield per unit of plant area of individuals of important forage species--all indicators of vigor--furnish more reliable and usable criteria than cover estimates for evaluating range condition.

FAHNESTOCK, GEORGE R. Cooperative logging slash research in the northern Rocky Mountains. Society of American Foresters Proc. Annual Meeting, 1954.

A description of the cooperative research program of the University of Idaho, U. S. Forest Service, and others, including statement of significant results of the first two year's work.

FRISCHKNECHT, NEIL C., and A. PERRY PLUMMER. A comparison of seeded grasses under grazing and protection on a mountain brush burn. Jour. Range Mangt. 8(4): 170-175, illus. July 1955.

Twenty-two grasses were seeded with smooth brome. After 9 years four rhizomatous species tended to dominate smooth brome under both grazing and protection, three rhizomatous species under grazing but not under protection, and two bunchgrasses under protection but not under grazing. Thirteen species were ultimately suppressed by smooth brome under both conditions. Heavy grazing reduced the yield of seeded grasses and encouraged invasion of sagebrush.

GLEASON, CLARK H., PAUL E. PACKER, and ROY D. HOCKENSMITH. Watershed damage...its signs and causes. American Forests. June 1955.

Describes the kinds of watershed damage that can be caused by fire, overgrazing, poor road building, mining operations, and poor logging practices.

JOHNSON, FRED W., and LOWELL ADAMS. Some lessons from Europe in forest-big game management. Jour. Forestry 53(6): 436-438. June 1955.

In Europe fences are used to exclude herbivores where they are preventing reforestation. Similar measures are suggested for America. Cost analysis indicates this method is economically feasible.

JULANDER, ODELL. Deer and livestock relations in Utah. Utah Acad. Sci., Arts & Letters Proc. 32: 202-203. 1955.

Deer and livestock forage habits and grazing capacity for the different kinds of grazing animals are discussed. It is desirable to graze both deer and livestock in properly balanced numbers to produce maximum numbers of grazing animals and also to maintain a favorable ecological balance in vegetation.

JULANDER, ODELL. Ecology of deer-livestock foothill ranges in Utah. Proc. 34th Ann. Conf. Western Assoc. State Game and Fish Comm., Las Vegas, Nevada, May 1954. 1955.

Drastic ecological changes have been brought about by excessive grazing of sheep, cattle, and deer. Good condition range is compared with those overgrazed by each of these animals and by combinations of deer and livestock.

JULANDER, ODELL. Deer and cattle range relations in Utah. Forest Science 1(2): 130-139, illus. June 1955.

Summarizes foods eaten by deer and cattle on several range types on summer and winter ranges and shows areas of intensive use by deer and by cattle on Oak Creek deer-cattle range. Factors affecting forage competition are outlined and suggestions made for managing big game-livestock ranges.

JULANDER, ODELL. Determining grazing use by cow-chip counts. Jour. Range Mangt. 8(4): 182. July 1955.

On crested wheatgrass pastures, rate of defecation was 11.5 cow chips per cow day. Wide variability of utilization and need for adequate sampling are stressed.

LEAPHART, CHARLES D. Preliminary observations on a current outbreak of western gall rust (Cronartium coleosporioides). U. S. Dept. Agr., Plant Disease Reporter 39(4): 314-315. 1955.

Considerable damage in scattered ponderosa pine stands along the Clark Fork River between Missoula and Superior in western Montana is reported. The outbreak has been building up for the past 15 to 20 years; and judging from an analysis of the living galls, shows no signs of abating.

LEAPHART, CHARLES D., and LAKE S. GILL. Lesions associated with pole blight of western white pine. Forest Science 1(3): 232-239. September 1955.

In a study of lesions associated with pole-blighted western white pine trees certain associations with the disease were suggested. A marked reduction in radial growth in the lower stem usually occurs before crown symptoms of the disease appear. The study indicated that reduced radial growth is always associated with pole blight and precedes both crown decline and lesion development. Although lesions are generally associated with pole-blighted trees, they apparently are not directly responsible for the progressive decline of diseased trees.

MARSTON, R. B. Is the world's rainiest rain forest in southern Davis County, Utah? Utah Acad. Sci., Arts, & Letters. 1955.

Compares maximum rates of infiltration of water in an oakbrush patch in Utah with rates reported for a waterspreading project at Seabrook Farms, New Jersey.

MIELKE, JAMES L. Refrigerator storage prolongs aeciospore color and viability. Mycologia 47(1): 149. 1955.

The natural yellow or orange color of fresh, mature aecia, which rapidly fades to a whitish color in a few months at room temperatures, may be prolonged for 2 years or more and viability of the spores greatly lengthened by placing the specimens in paper bags and storing them in a refrigerator at temperatures between 5° - 7° C., (41° - 45° F.). Excellent results have been obtained with four species of rusts: _Cronartium filamentosum_, _C. stalactiforme_, _C. comandrae_, and _Peridermium harknessii_.

MUEGGLER, W. F., and J. P. BLAISDELL. Effect of seeding rate upon establishment and yield of crested wheatgrass. Jour. Range Mangt. 8(2): 74-76. March 1955.

From seeding crested wheatgrass on the Snake River Plains in southern Idaho at 2, 4, 8, 12, and 24 pounds per acre, it is concluded that all rates will produce satisfactory stands, although longer periods of protection are required to achieve full stands for the lighter than the heavier rates. Heavy seeding is not a cause of stand failure from excessive competition between seedlings, as is sometimes asserted.

NEILS, GEORGE, LOWELL ADAMS, and ROBERT M. BLAIRE. Management of white-tailed deer and ponderosa pine. Proc. 20th North Amer. Wildlife Conf. pp. 539-551. 1955.

Deer destroy all seedling pines that escape other lethal factors on a winter deer range in northwestern Montana. Inside fenced study plots reproduction is adequate. The estimated annual loss is $90,000 on the winter range. Suggested remedies are increased hunter harvest and fencing.

ROE, ARTHUR L. Cutting practices in Montana larch—Douglas-fir. Northwest Science 29(1): 23-34. 1955.

An appraisal of cutting practices in the western larch—Douglas-fir timber type based upon recent studies in western Montana. Shelterwood, seed-tree, and clear cutting systems are compared as to natural regeneration and growth of reserve trees. Adequate larch reproduction can be expected when 40 percent or more of the area is in favorable seedbed and an adequate seed source is present (8 to 10 trees per acre during an average seed year). Net annual growth per acre for the 5-year period following cutting was 51 board feet on the vigor selection shelterwood with a reserve of 18,800 board feet, -437 board feet on the economic selection shelterwood with a reserve of 7,000 board feet, and 9 board feet on the seed-tree cutting with a reserve of 5,400 board feet.

TACKLE, DAVID. A preliminary stand classification for lodgepole pine in the Intermountain region. Jour. Forestry 53(8): 566-569. August 1955.

A classification for lodgepole pine stands based upon age, structure and composition. The principal factors which cause stand variation (elevation, aspect, fire, cutting, insects, disease, wind, snow, and soil) are discussed and stand descriptions are presented. The usefulness and applicability of the classification are described.

C. Processed reports

ANDERSON, I. V. Ponderosa pine tree grades and use for appraisal of timber quality. Mimeo. March 1955.

Describes tentative ponderosa pine tree grades based on observations of growth and lumber yield through the different life stages of the tree and outlines procedures for applying tree grades to stumpage appraisals.

ANDERSON, I. V. Engelmann spruce--its properties, uses, and production. F.P.R.S. 1955.

Describes the broad utility of Engelmann spruce as a commercial softwood and cites the growing demand for this species.

BASILE, JOSEPH V., and RALPH C. HOLMGREN. Artificial revegetation studies on depleted big-game winter ranges in Idaho. Job Completion Reports, Project W 111-R-1. Idaho Fish and Game Dept., mimeo., 23 pp. 1955.

Survey of past field-scale revegetation trials in southwester Idaho; results of seeding tests, evaluating effects of rodents, competition, and time of seeding; mortality due to browsing and trampling by deer; results of depth-of-seeding trials; plans for further browse-revegetation studies.

BEHRE, C. EDWARD, and S. BLAIR HUTCHISON. Future supply and quality of domestic timber. Chapter 6, Timber Resource Review. U. S. Dept. Agr., U. S. Forest Service. 43 pp., illus. 1955. (Preliminary Review Draft)

An analysis of the long-range timber outlook in the United States to the year 2000. Prepared as part of the Forest Service's Timber Resource Review of 1955.

COLE, WALTER E. A method for sampling populations of the pine butterfly, Neophesia menapia (F&F) (Thesis) Colorado A&M College, Fort Collins, Colo. 1955. (In partial fulfillment of the requirements for a Master of Science degree.)

A pine butterfly egg sampling method developed during the 1953-54 epidemic of pine butterfly, for determination of sampling intensities and relating number of eggs per twig with subsequent damage.

COPELAND, OTIS L., JR., and CHARLES D. LEAPHART. Preliminary report on soil-rootlet relationships to pole blight of western white pine. Research Note 22, 6 pp. December 1955.

Results obtained from a study of 6 healthy and 11 diseased 1-acre plots, well distributed throughout the western white pine type, indicate that pole blight is significantly correlated with certain physical soil characteristics and rootlet mortality. These soil factors are effective depth and available water storage capacity, the latter being the most important.

CURTIS, JAMES D. A study of ponderosa pine production in central Idaho. Misc. Pub. 4, 9 pp., illus. June 1955.

Outlines a study designed to test in combination two methods of reproduction, two levels of reserve, logging by two sizes of tractor, in initial stands of low, medium, and high volumes per acre. Also included are a means of sawtimber growth prediction according to treatment, assessment of disturbance of stocking from logging, and plans for gauging the effectiveness of timber stand improvement and regeneration techniques.

CURTIS, JAMES D. Forest management research by the Intermountain and Northern Rocky Mountain Stations. A bibliography, 1912 through 1954. Misc. Pub. 6, 42 pp. December 1955.

Lists the publications of the Forest Management Research Division together with selected works of other divisions considered useful to the student, teacher, and forest manager.

CURTIS, JAMES D. Effects of origin and storage method on the germinative capacity of ponderosa pine seed. Research Note 26, 5 pp. December 1955.

Analysis of viability tests showed that storage method, and to a lesser extent altitudinal location of parent trees, affects the germinative capacity of seed collected from stands in the Boise Basin in central Idaho. After 14 years, seed from young (50-70 years) open grown trees at 5,500 feet and stored at 32° F. had the highest germination (74.7 percent) and seed from scattered old trees (200-350 years) at the same altitude in above ground cellar had the lowest (44.7 percent). Interaction of variables was significant indicating a difference in germinative capacity for a particular origin depending on the storage method.

DIETERICH, JOHN H., and CHARLES E. HARDY. Rating the 1954 fire season in Region 1 of the Forest Service. Research Note 16, 5 pp. March 1955.

Describes the rating of the severity of the 1954 fire season as measured by burning index and lightning occurrence. Compares the 1954 fire season in the region and on each national forest with the ratings for each year from 1934 through 1953.

DIVISION OF FOREST ECONOMICS. Economics research needs related to wild land management and development in the Mountain States. Research Paper 38, 27 pp., illus. January 1956.

A review of resource problems in the Rocky Mountain States that warrant economic analysis. Covers individual problems in timber, range, water, and wildlife management. Problems in marketing and area management are also covered. Contains a general description of the whole area and briefer descriptions of each problem.

EVANKO, ANTHONY B. Species adaptability and seeding season for increased forage production in northeast Washington. Research Paper 37, 25 pp., illus. February 1955.

Numerous species are rated, on the basis of small plot tests, at three adaptation nurseries, a lodgepole burn, and a logging area. Spring seedings have been more successful than fall seedings.

EVANKO, ANTHONY B. Early spring grazing values for four seeded species on abandoned cropland in northeast Washington. Research Note 18, 4 pp. May 1955.

Intermediate, crested, and pubescent wheatgrasses, and smooth brome, greatly outproduced the weedy vegetation of abandoned cropland. Intermediate wheatgrass was especially early and productive.

FOILES, MARVIN W. Thinning from below in a 60-year-old western white pine stand. Research Note 19, 6 pp. May 1955.

Thirty-year results of one test show that light, moderate, and heavy thinnings all increased diameter growth of dominant and codominant trees. Thinning improved the value by increasing the proportion of high-value white pine. Volume growth following light thinnings was about the same as for the uncut stand. The heavy thinning reduced volume growth.

GRAHAM, DONALD P. Distribution of pole blight of western white pine. Research Note 15, 3 pp. March 1955.

Disease surveys conducted in 1953 and 1954 reveal only minor extensions of pole blight beyond the previously known range. The acreage of western white pine affected by pole blight is now estimated to be between 90,000 and 95,000 acres of moderate to severe damage. There is an undetermined acreage with scattered pole blight trees where damage may later become appreciable.

HARDY, CHARLES E., CHARLES E. SYVERSON, and JOHN H. DIETERICH. Fire-Weather and Fire-Danger Station Handbook. Misc. Pub. 3, 84 pp., illus. April 1955.

A comprehensive guide outlining methods for locating, equipping, operating, inspecting and using fire-weather and fire-danger stations. Contains complete information on fire-weather instruments. Includes sections on cloud identification and burning index rating. This handbook is the standard guide for forest fire-danger rating activities in the Intermountain West.

HERRINGTON, ROSCOE B. Montana Christmas tree shipments reach record high. Research Note 17, 5 pp. April 1955.

Numbers of Christmas trees shipped from various Montana counties by rail and truck, and numbers shipped to most important state markets.

HERRINGTON, ROSCOE B. Northern Rocky Mountain pole production in 1954. Research Note 24, 4 pp. December 1955.

Numbers of poles produced in 1954 in Montana, north Idaho, and northeast Washington. Production by species and source is also given. Proportions by length and A.S.A. class are shown.

KECK, WENDELL M. The Forest Service answer to "Why Study English?" Mimeo. January 1956.

"The magic of words lies in the power they have, when properly chosen and arranged, to convey to other people what we wish them to know what is in our minds."

LAMMI, J. O. Statistics on western wild land resources. Research Paper 31 (Rev.), 24 pp. July 1955.

A collection from numerous sources of available statistics on wild land resources in Regions 1 and 4 of the Forest Service. Contains data on water, timber, recreation, wildlife, livestock, and land and population.

McCOMB, DAVID. Relationship between trap tree felling dates and subsequent Engelmann spruce beetle attack. Research Note 23, 5 pp., illus. December 1955.

Describes tests to determine the effect of felling spruce trees several periods of the year for trapping of beetles. Measurements of effectiveness based on beetle attacks per square foot of bark surface.

MacCREADY, PAUL B., JR., VINCENT J. SCHAEFER, JOHN H. DIETERICH, and J. S. BARROWS. Project Skyfire: Cloud and Lightning Observation Handbook. Misc. Pub. 5, 47 pp., illus. June 1955.

This handbook provides a guide for cloud and lightning observation in western forests, including cloud identification, cloud measurements, and the mapping of lightning storms. The handbook is a standard reference for Project Skyfire lookout stations and workers engaged in lightning fire research.

MARSTON, R. B. Infiltration rates of two waterspreading projects, Davis County, Utah. Research Note 20, 5 pp., illus. June 1955.

Describes two kinds of waterspreading projects in Davis County, Utah and presents data on the total amount of water handled by each project as well as the maximum rates of infiltration.

MOESSNER, KARL E. The accuracy of stand height measurements on aerial photos in the Rocky Mountains. Research Note 25, 5 pp. December 1955.

Discusses problems of measuring tree heights on aerial photos of rough mountainous areas. Brings out that acceptable measurements can be made if care is used. Gives relative accuracy of measurements on different scale photos.

OLSON, D. S., and GEORGE R. FAHNESTOCK. Logging slash--A study of the problem in Inland Empire forests. Univ. of Idaho Bul. No. 1, 52 pp., illus. July 1955.

Analysis of the logging slash problem in relation to all types of forest values and uses, description of research being done on slash by the University of Idaho and the U. S. Forest Service, and results of that research to date.

WIKSTROM, JOHN H. Pulpwood production in Idaho and Montana, 1954. Research Note 21, 2 pp. July 1955.

Numbers of cords of pulpwood produced during 1954 in north Idaho, south Idaho, eastern Montana, and western Montana. Gives change in production since 1952 and some indication as to species.

ZILLGITT, WALTER M., and ROLAND ROTTY. Factors affecting future supply and quality of domestic timber, C. Forest tree planting. Chapter 4, Timber Resource Review. U. S. Dept. Agr., U. S. Forest Service. 32 pp., illus. 1955. (Preliminary Review Draft)

This 1952 appraisal of planting shows that forest plantations now cover about 5 million acres in the United States. The area still to be planted, however, totals 52 million acres. The rate of planting has increased greatly in recent years and is expected to reach eventually a level of 800 thousand acres of acceptable plantations a year. Reforestation of the entire plantable area could in time add as much as 8 billion board feet a year to the national timber harvest.